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#217 JUNE 2023

Sky at Night

THE UK'S BEST-SELLING ASTRONOMY MAGAZINE

NIGHT SKIES IN DANGER

Can we save our view of the stars?

PLANETARY NEBULAE

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HOW THE SOUTHERN STARS WERE MAPPED

THE SCIENCE BEHIND NIGHT-SHINING CLOUDS

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Welcome

Safeguarding our dark skies should concern us all

Back in our March issue, we reported on a worrying new study into skyglow, the diffuse illumination caused by light pollution. Based on over a decade of night-sky observations by citizen scientists, it found that the night sky has brightened by an average of 9.6 per cent each year. In this issue, science writer Shaoni Bhattacharya speaks to one of the study's authors and looks at the state of play of legal proposals to tackle light pollution – something that should be a concern for everyone. Turn to **page 28** to read more.

We hear too about the often-frustrating individual experience of combating light pollution from amateur astronomer Stephen Kirkman on **page 25**, and we remember the dedication of Bob Mizon, national coordinator for the BAA's Commission for Dark Skies on **page 14**, who passed away in April.

Also this month, we're marking the achievements of two remarkable women: 60 years ago, Valentina Tereshkova became the first woman in space, followed 20 years later by Sally Ride, the first American woman to travel out of Earth's atmosphere. Read about their inspiring stories in Ezzy Pearson's feature on **page 34**.

It's the start of noctilucent cloud season and on **page 46** of this month's Sky Guide, Pete Lawrence explains how to look for these ethereal clouds, the highest in our atmosphere. Then on **page 60**, science journalist Rob Banino takes a look at the latest research into these night-shining clouds and whether they're becoming more common. Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on Thursday 15 June.

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Sky at Night – lots of ways to enjoy the night sky...

Television
Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 18

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The Sky Guide

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New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**

This month's contributors

Ezzy Pearson

Features editor

"With the Artemis landing growing ever closer, it's a poignant time to look back at the pair who led the way into the heavens for all womankind." **Ezzy tells us about the first women in space,** page 34

Rob Banino

Science journalist

"Records show noctilucent clouds are on the rise, and future missions to study them could reveal more about our planet's changing atmosphere." **Rob explores what's causing an increase in NLCs,** page 60

Katrin Raynor

Astronomy writer

"Equinoxes and solstices mark the seasons throughout the year, and on 21 June we'll experience the summer solstice – the longest day of the year." **Katrin explains the astronomical basis for the seasons,** page 72

Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonus-content/GOKTED4** to access this month's selection of exclusive Bonus Content

JUNE HIGHLIGHTS

Interview: Astronaut Kathy Sullivan

The former NASA astronaut discusses her role in the launch of Hubble and what it's like to walk in space.

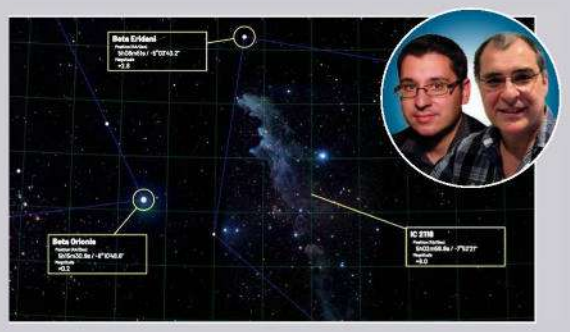
***The Sky at Night* Search for Alien Life**

Maggie and Chris return for a new series. Catch up as they explore how science is looking for life beyond our home planet.

Build your own EQ camera mount

Download PDF plans and extra images to help you make this month's DIY Astronomy project (find the details on page 74).

The Virtual Planetarium



Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

RASPBERRY SPACE COCKTAIL

When is a nebula not a nebula? When it's two nebulae in one

NICHOLAS U MAYALL TELESCOPE, 19 APRIL 2023

Captured by the Nicholas U Mayall 4-metre Telescope at the Kitt Peak National Observatory in Arizona using its new Mosaic-3 detector, this is LBN 867, the Raspberry Nebula, which lies in the constellation of Orion. Look more closely, though, and you can see that LBN 867 is actually three objects in one: two nebulae and a powerful main sequence star.

This blue-white star, HD 34989, lies at its heart. Surrounding it is the red emission nebula Sh2-263 – a diffuse region of hydrogen ionised by the heat and light energy coming from the star, and so giving off a reddish glow. Meanwhile, towards the bottom left of the photo, an adjacent cloud of cosmic dust is reflecting that same light, forming the blue reflection nebula vdB 38.

Somewhat confusingly, another celestial object is sometimes called the Raspberry Nebula – namely the planetary nebula IC 418 in the nearby constellation of Lepus (not seen here). But for sheer majesty, it can't quite compete with LBN 867's trio of delights.

MORE **ONLINE**

Explore a gallery of these and more stunning space images

KPNO/NOIRLAB/NSD/AURA/T.A. RECTOR (UNIVERSITY OF ALASKA ANCHORAGE/NSF'S NOIRLAB) IMAGE PROCESSING: T.A. RECTOR (UNIVERSITY OF ALASKA ANCHORAGE/NSF'S NOIRLAB) M. ZAMANI (NSF'S NOIRLAB) & D. DE MARTIN (NSF'S NOIRLAB)

△ Purple haze

IXPE/CHANDRA X-RAY OBSERVATORY, 10 APRIL 2023

Combining data captured by NASA's Imaging X-ray Polarimetry Explorer (IXPE) satellite and Chandra X-ray Observatory, this image shows the Crab Nebula, a supernova remnant some 6,500 lightyears from Earth that's also known as Taurus A, M1 or NGC 1952. The nebula was formed by a supernova that was recorded by Chinese astronomers in 1054, and the picture clearly shows the Crab Pulsar that lies at its heart, as well as the turbulent magnetic field that surrounds it.

Eighth wonder ▷

JAMES WEBB SPACE TELESCOPE, 6 APRIL 2023

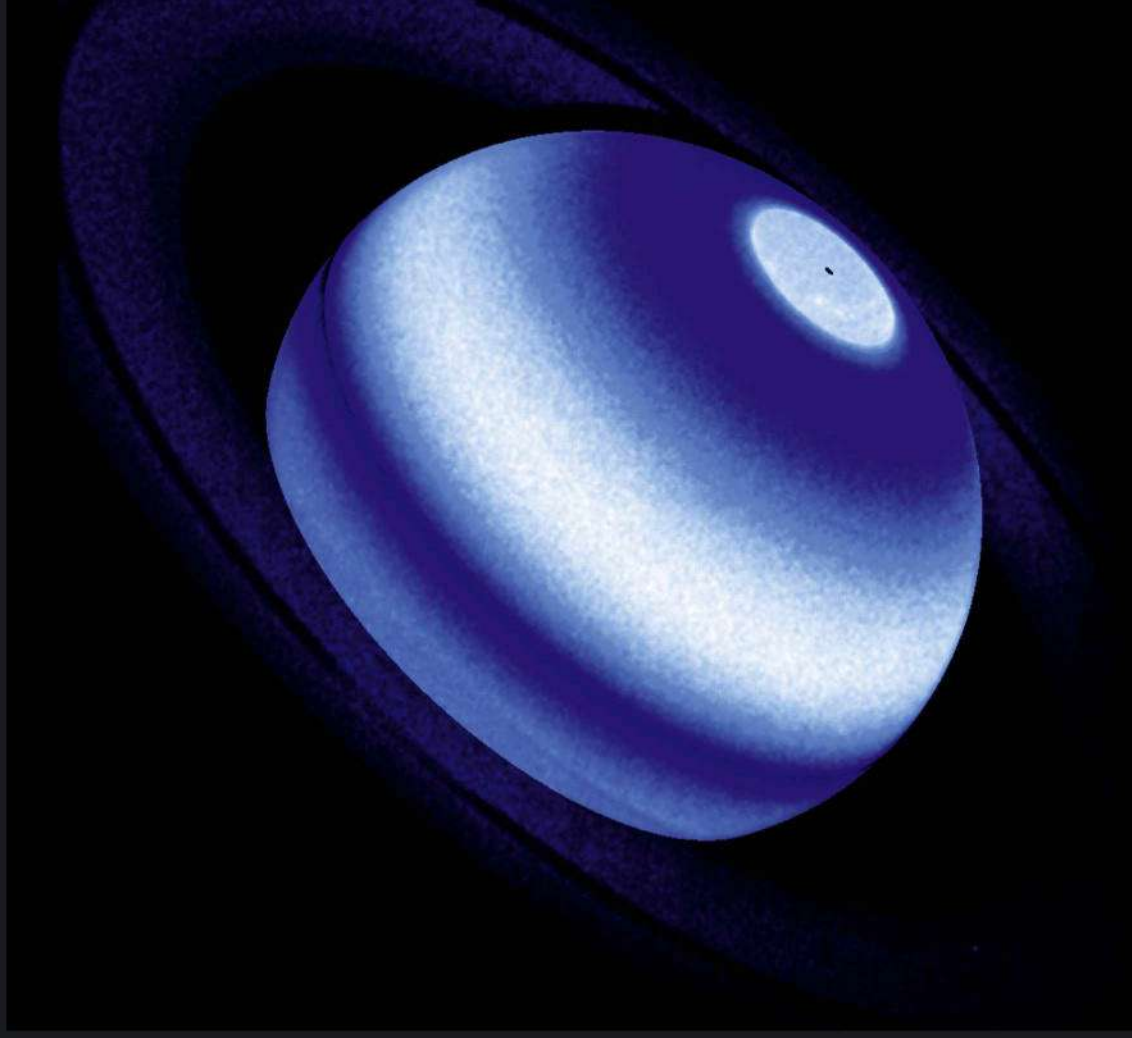
William Herschel speculated that Uranus may have a ring system way back in the 18th century, but it wasn't until 1977 that its existence was proven, while our first images of the rings were provided by Voyager 2 in 1986. Those first grainy black and white pictures can't compare, though, to this stunning new JWST image which shows 11 of the 13 known rings, as well as an area of brightening at the planet's northern pole, which currently faces the Sun.

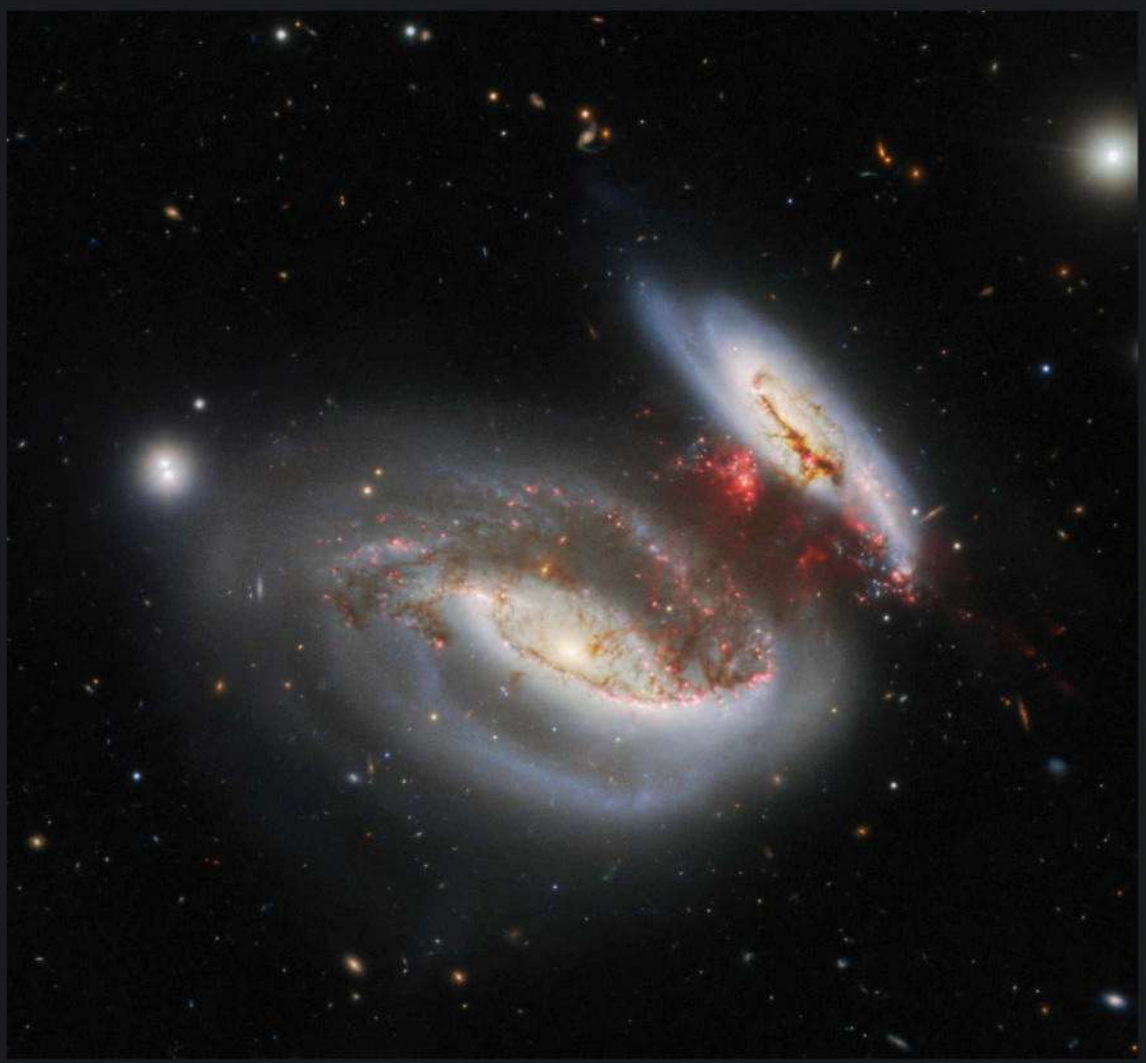
X-RAY (IXPE: NASA) (CHANDRA: NASA/CXC/SAO), NASA/ESA/CSA/STSCI, NASA/ESA/LOTFI BEN-JAFFEL (IAP & LPL), INTERNATIONAL GEMINI OBSERVATORY/NOIRLAB/NSF/AURA

A hard rain's gonna fall ▷

HUBBLE SPACE TELESCOPE/ CASSINI/VOYAGER, 30 MARCH 2023

You'd expect icy particles falling from space to have a chilling effect, but as this UV image of Saturn shows, that's not necessarily true. Generated using UV data from the Voyager 1, Voyager 2, Cassini, Hubble and International Ultraviolet Explorer missions, it shows a band of higher UV radiation below Saturn's rings, denoting higher temperatures – thought to be caused by particles hitting the upper atmosphere. It's hoped this discovery may help astronomers identify which exoplanets also have rings.





◁ Head-on collision

GEMINI NORTH, 29 MARCH 2023

This image captured by the Gemini North telescope shows the aftermath of a head-on collision between the two Taffy Galaxies, UGC 12914 (left) and UGC 12915 (right), which lie about 180 million lightyears from Earth and smashed into one another 25–30 million years ago. Galaxy collisions often result in a redistribution of gas and the formation of new stars, but this one created a 'bridge' between the two, thought to be too turbulent for star formation to occur.

This was Sylvia's promise to you...

A generation ago, a woman named Sylvia made a promise. As a doctor's secretary, she'd watched stroke destroy the lives of so many people. She was determined to make sure we could all live in a world where we're far less likely to lose our lives to stroke.

She kept her promise, and a gift to the Stroke Association was included in her Will. Sylvia's gift helped fund the work that made sure many more of us survive stroke now than did in her lifetime.

Sylvia changed the story for us all. Now it's our turn to change the story for those who'll come after us.

Stroke still shatters lives and tears families apart. And for so many survivors the road to recovery is still long and desperately lonely. If you or someone you love has been affected by stroke – you'll know just what that means.

But it doesn't have to be like this. You can change the story, just like Sylvia did, with a gift in your Will. All it takes is a promise.

You can promise future generations a world where researchers discover new treatments and surgeries and every single stroke survivor has the best care, rehabilitation and support network possible, to help them rebuild their lives.

Big or small, every legacy gift left to the Stroke Association will make a difference to stroke survivors and their families.

Find out how by calling 020 7566 1505
or email legacy@stroke.org.uk
or visit stroke.org.uk/legacy

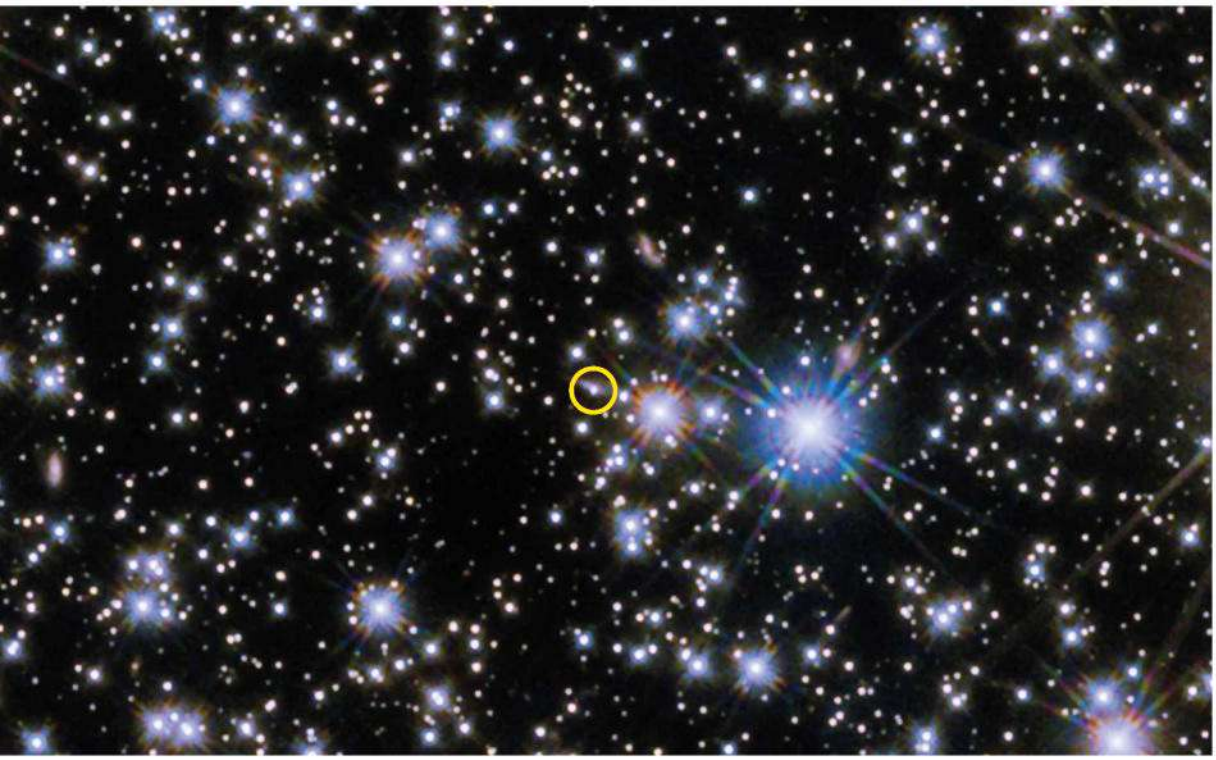
Rebuilding lives after stroke

The Stroke Association is registered as a charity in England and Wales (No 211015) and in Scotland (SC037789).
Also registered in the Isle of Man (No. 945) and Jersey (NPO 369), and operating as a charity in Northern Ireland.

Stroke Association

The latest astronomy and space news, written by Ezzy Pearson

BULLETIN



▲ The massive GRB pulse on 9 October 2022 (ringed) was so bright it effectively blinded many observatories

NASA/ESA/CSA/STSCI/A. LEVAN (RADBOUD UNIVERSITY)
IMAGE PROCESSING: GLADYS KOBER

The brightest radiation flash on record

Gamma-ray burst declared a 1-in-10,000-year event

A flash of radiation called a gamma-ray burst (GRB) which swept across Earth last year was the brightest on record, astronomers have recently been able to confirm. Seen on 9 October 2022, it's believed such blasts only occur once every 10,000 years.

The event is called GRB 221009A, though it has been nicknamed the BOAT – the brightest of all time. GRBs are thought to be created when a large star's core collapses to form a black hole, which then quickly ingests the gas surrounding it before blasting the material out at near to light speed.

These jets emit powerful gamma and X-rays that can cross the Universe. Observatories around the world look out for these signals as they pass over Earth, but the BOAT was so bright it over-saturated most of them. Fortunately, NASA's Fermi Gamma-ray Space Telescope made out the burst, revealing it was 70 times brighter than any previously observed. Its light has been travelling for around 1.9 billion years, making it one of the closest ever detected.

"Being so close and so bright, this burst offered us an unprecedented opportunity to gather observations of the afterglow across the electromagnetic spectrum and to test how well our models reflect what's really happening in GRB jets," says Kate Alexander from the University of Arizona.

It will allow astronomers to study what produces black hole jets, the process of which is not well-understood, but may be driven by the black hole's magnetic field. One piece of the puzzle is missing, however: there is no sign of the supernova that created the black hole, possibly due to dust in the Milky Way blocking its light.

"We cannot say conclusively that there is a supernova, which is surprising given the burst's brightness," says Andrew Levan from Radboud University in the Netherlands. "If it's there, it's very faint. We plan to keep looking, but it's possible the entire star collapsed straight into the black hole instead of exploding." **fermi.gsfc.nasa.gov**

Comment

by Chris Lintott

Impressive though GRB 221009A was, and valuable in understanding these spectacular events and the physics of black holes, it has a way to go to claim the title of the BOAT – or even to claim to be the BOAOHH (brightest of all of human history).

Ancient cedar trees in Japan preserve a ring of an isotope of carbon called carbon-14, dating back to AD 774. Ice deposited in Antarctica shows beryllium dating from the same time.

According to a 2013 paper, both of these phenomena are explained by the arrival of a burst of high-energy cosmic rays associated with a gamma-ray burst in our own Milky Way. If only we'd had gamma-ray telescopes in the 8th century, GRB 221009A would be firmly in second place.

Chris Lintott co-presents *The Sky at Night*

▲ **Left (clockwise from top): Victor Glover, Jeremy Hansen, Reid Wiseman and Christina Koch, the Artemis II crew announced in April. Right: debris on the launch pad in Texas after SpaceX Starship's 'rapid unscheduled disassembly' four minutes into its test flight**

One step forward for Artemis...

The Moon mission's latest triumph has been followed by a potential new setback

NASA's Artemis programme has taken a giant leap forward, but also a small step back on its journey towards setting the first woman and first person of colour on the Moon's surface in the next few years.

On 3 April, NASA announced the four crew members who would take part in the Artemis II mission, which is currently scheduled for 2024. The crew will consist of veteran NASA astronauts Reid Wiseman, Victor Glover and Christina Koch, the latter of whom has already made history by taking part in the first all-female spacewalk alongside Jessica Meir. They will be joined by first-time astronaut Jeremy Hansen from the Canadian Space Agency.

The Artemis II crew will be the first to launch into space on the Space Launch System (SLS) rocket and to travel in the Orion crew module. This mission won't set down on the lunar surface, but will instead fly a figure-of-eight path around the Moon before returning to Earth. This will serve as a test of all the spacecraft's systems and procedures.

If all goes well, the Artemis III crew will attempt a landing a year or so later. They will head to the lunar surface in a variation of SpaceX's Starship, which had its first full test launch on 20 April. The vehicle made it off the launch pad at the company's Starbase facility in Boca Chica, south Texas, despite only 27 out of its 33 Raptor engines firing. However, at 39km altitude several issues forced SpaceX to 'order a rapid unscheduled disassembly before stage separation', as the company referred to the rocket's explosion on Twitter.

Although the explosion was not regarded as a disaster – SpaceX's main goal was getting the rocket off the launch pad, so they classed the mission as a success – the launch did cause extensive damage to the launch pad. The powerful thrusters blew a crater in the concrete, while flying debris damaged the surrounding infrastructure.

SpaceX had been preparing a water-cooled steel plate to distribute the heat of the launch, but it wasn't ready for the test. As previous static fire tests suggested the pad could withstand a single launch, they proceeded – despite the previous tests not being done at full power. The company hopes to repair the pad and return to operations within a few months, but the damage could prove to be a backwards step for Artemis. **www.nasa.gov**

NASA, PATRICK T. FALLON/GETTY IMAGES, R.-S. LU (SHAO) E. ROS (MPIFR) S. DAGNELLO (NRAO/AUI/NSF) JODY AMIET/GETTY IMAGES, NASA/ESA/G. BACON (STSCI)

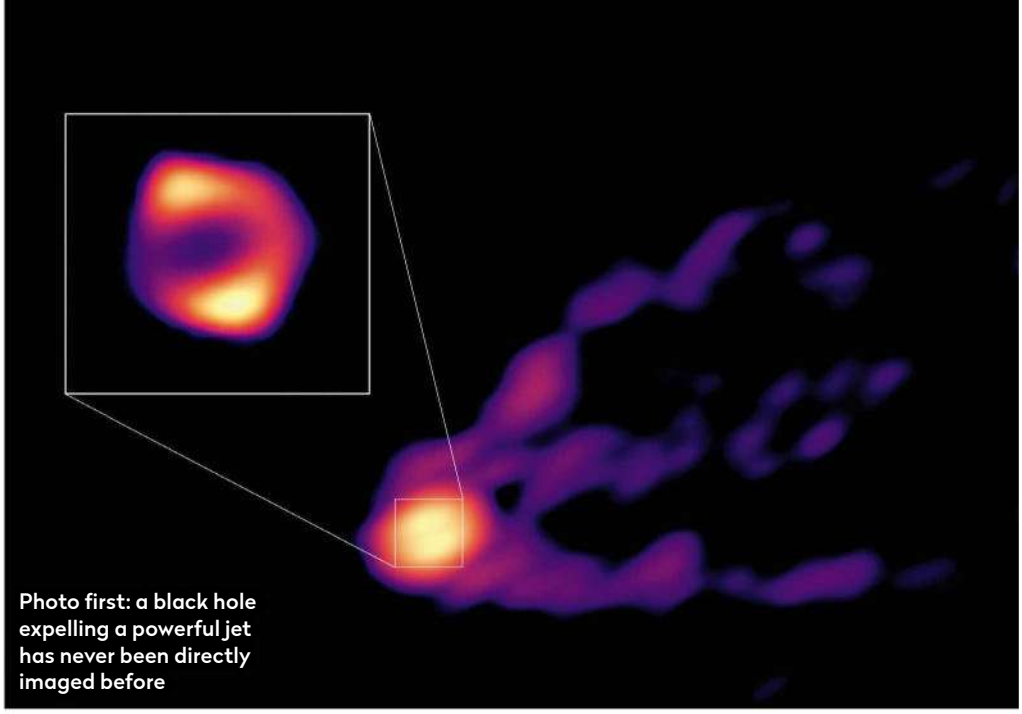


Photo first: a black hole expelling a powerful jet has never been directly imaged before

Black hole jet origin seen for first time

New observations hint at causes of powerful jets

For the first time, astronomers have captured both the shadow of a black hole and its powerful jet in the same image. The picture of the heart of galaxy M87 was taken in 2018 using radio observatories around the world working as one to create a single, Earth-sized telescope, but it has taken several years to process the data.

"We know that jets are ejected from the region surrounding black holes," says Ru-Sen Lu from the Shanghai Astronomical Observatory, China, "but we still don't fully understand how this happens. To study this directly we need to observe the origin of the jet as close as possible to the black hole."

M87's black hole made history as the first to be imaged by the Event Horizon Telescope in 2019, but the new studies were at 3.5mm rather than 1.3mm. At these longer wavelengths, the team saw the region where the jet connects with the ring of emission around the central supermassive black hole, which will give key insights into how these jets form. **www.eso.org**

JUICE begins its journey

The Jupiter Icy Moons Explorer (JUICE) from the European Space Agency is on its way, following a successful launch at 12:14 UTC on 14 April from French Guiana.

The launch was scheduled for the previous day, but was put on hold due to bad weather. The spacecraft unfurled its solar wings around 90 minutes later, but it will spend the next few months deploying and testing its instruments as its continues its journey to Jupiter.

It will have plenty of time, as JUICE will not arrive at the planet until July 2031. It will conduct several fly-bys of the icy moons Europa, Callisto and Ganymede, taking detailed measurements of their surface geology, composition and magnetic fields. It will then eventually enter orbit around Ganymede in December 2034.

The mission is the first dedicated to studying these icy worlds. One key area of study is the liquid water oceans thought to lie beneath the surface of all three moons, considered to be one of the most likely places to find life beyond our planet.

JUICE atop an Ariane 5 rocket lifts off for its eight-year trip

"The treasure trove of data that ESA's JUICE will provide will enable the science community worldwide to dig in and uncover the mysteries of the Jovian system, explore the nature and habitability of oceans on other worlds and answer questions yet unasked by future generations of scientists," says Carole Mundell, ESA's director of science. **www.esa.int**

NEWS IN BRIEF

Life-friendly stars

Metal-poor stars could be more likely to host life. New simulations show stars rich in metals emit ultraviolet light that could prevent their planets from forming ozone layers. As stars become enriched with metals with each successive generation, the find may mean the Universe is becoming increasingly unfriendly to complex life as it ages.

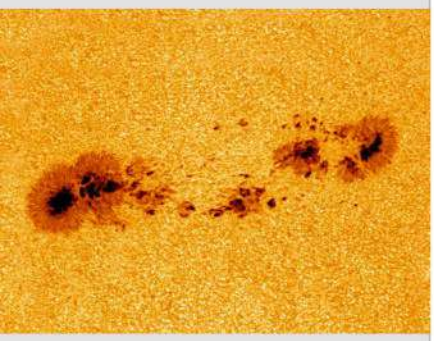
Virgin Orbit collapses

Virgin Orbit has filed for Chapter 11 bankruptcy. The company has struggled to increase its launch rate over the last two years but had a major setback in January when its first rocket launch from British soil failed due to a dislodged fuel filter in the propulsion system.

Lunar failure

The Hakuto-R lunar lander from private Japanese spaceflight company iSpace has become the latest to bite the Moon dust after it failed to touch down on 25 April. The lander lost contact shortly before landing, but appears to have unexpectedly accelerated and crashed into the Moon. iSpace still plans to move ahead with its scheduled second mission in 2024.

NEWS IN BRIEF



Early solar maximum?

The current Solar Cycle 25 could be heading towards a peak in sunspot numbers in late 2023 or early 2024, a full year earlier than predicted. The current solar cycle has been outpacing predictions for several months, causing solar physicists to reevaluate their forecasts.

No magnets for meteorites

Meteorite collectors have long used magnets to identify potential space rocks, but these could be damaging their scientific potential. Experiments found hand magnets can wipe away the internal magnetic fields of meteorites. Instead, researchers recommend having potential meteorites verified by a professional.

Slow but strong

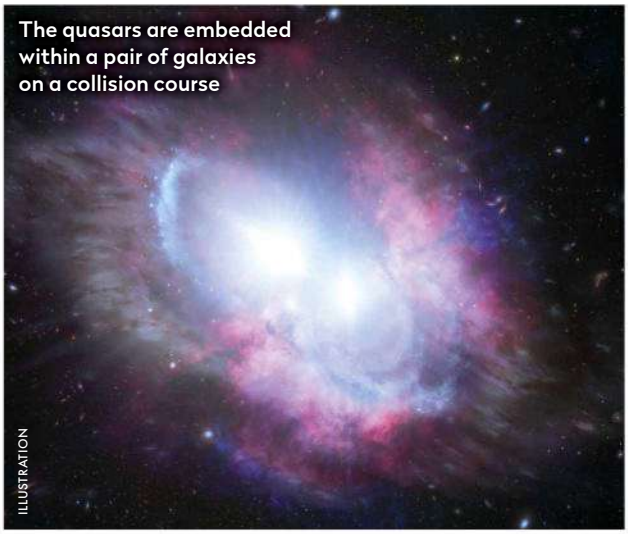
The neutron star at the heart of pulsar J0901-4046 is rotating at the slowest rate of all known pulsars and is so sluggish it should have stopped emitting radio signals. However, it has been found to be the most magnetised pulsar, with a field 30 trillion times stronger than a fridge magnet, which could help keep the pulsar's heart beating.

OLIVER SCHNEIDER/CCDGUIDE.COM, INTERNATIONAL GEMINI OBSERVATORY/NOIRLAB/NSF/AURA/M. ZAMANI/J. DA SILVA, CFDS

BULLETIN

Double quasar shines brightly

The pair are close to merging into a single giant black hole



The quasars are embedded within a pair of galaxies on a collision course

ILLUSTRATION

A duet of extremely active black holes discovered in the heart of a distant galaxy are believed to be just 10,000 lightyears apart, according to the latest observations.

The pair, known as J0749+2255, are thought to be quasars. These are supermassive black holes gorging on the gas surrounding them, with the turbulence from this feeding frenzy superheating the gas, causing it to glow exceptionally brightly.

The two were most likely to have been brought together during a merger of two galaxies that will eventually form a giant elliptical galaxy. The pair are so far away we are seeing them as they were when the Universe was just three billion years old.

"We don't see a lot of double quasars at this early time in the Universe. And that's why this discovery is so exciting," says Yu-Ching Chen of the University of Illinois Urbana-Champaign, who led the follow-up study using the Hubble Space Telescope. **hubblesite.org**

Dark skies champion Bob Mizon passes away

Dark-sky campaigner Bob Mizon, who spent many years fighting to protect the night from light pollution, passed away on 19 April.

Born in 1946, Mizon helped to establish the British Astronomical Association's Commission for Dark Skies (CfDS) in 1989 and became its national coordinator soon after its inception. In this role, he promoted responsible lighting throughout the UK and Europe. He was instrumental in helping Cranborne Chase AONB achieve its status as an International Dark Sky Reserve, and was one of the instigators of the UK government's All-Party Parliamentary Group for Dark Skies.

He spent 26 years working as a French teacher, during which time he helped run school astronomy clubs and translated French astronomy books into English, before becoming a full-time planetarium operator in 1996. Nearly 150,000 children and adults all over Britain experienced Mizon's infectious enthusiasm for astronomy and nature in the Mizar Travelling Planetarium.

Bob Mizon (right) helped Cranbourne Chase AONB achieve Dark Sky status in 2017

His work was officially acknowledged when he was awarded an MBE for voluntary services to astronomy and the environment in 2010. **britastro.org/dark-skies**

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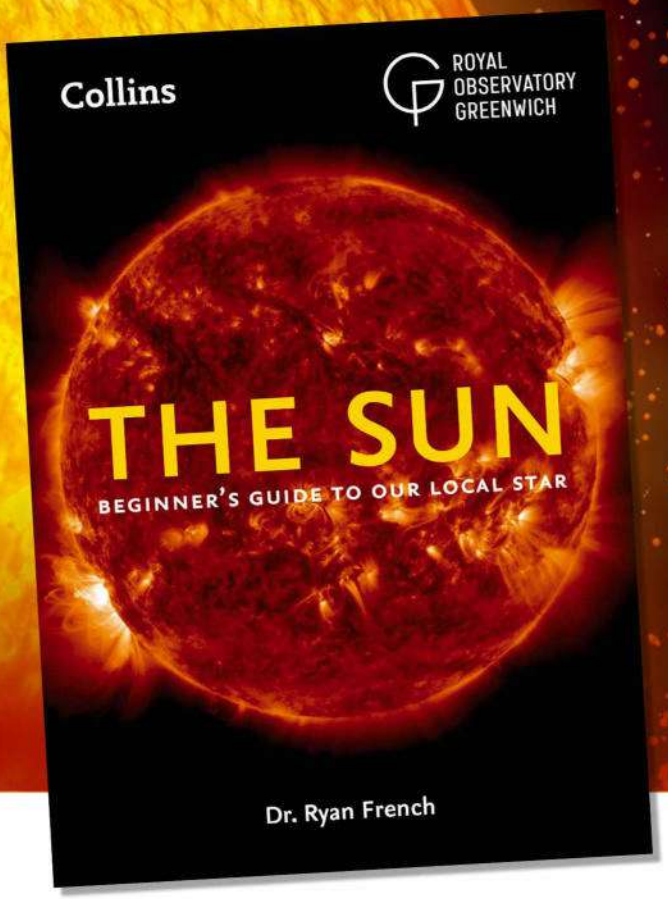

A BEGINNER'S GUIDE TO UNCOVERING THE MYSTERIES OF THE SUN

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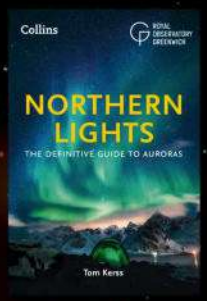

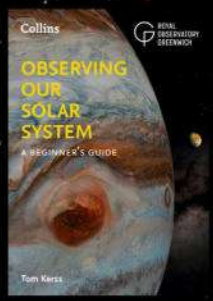

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Our experts examine the hottest new research

CUTTING EDGE

What if Earth was bigger and further from the Sun? Pandemonium seems to be the answer

ILLUSTRATION

GETTY; NASA/ESA AND J. KASTNER (RIT)

Super-Earths wreak havoc

Simulations show the common planet type would cause chaos in our Solar System

The more we've learned about the planetary systems orbiting other stars in the galaxy, the more we've realised just how unusual our own Solar System is. Most exoplanetary systems have very different architectures to our own. The Kepler-11 system, for example, is exceedingly compact, with six planets crammed within the equivalent orbit of Venus. Other systems contain worlds with extremely elliptical orbits – such as HD 20782 b – which indicate significant past effects of gravitational interactions between planets. And one of the most common kinds of exoplanets to turn up in our astronomical searches is not present at all in the Solar System: super-Earths. Super-Earth planets have a mass several times larger than Earth's but substantially less than ice giants like Uranus and Neptune.

Stephen Kane, in the Department of Earth and Planetary Sciences at the University of California, Riverside, was curious to see how differently our Solar System might have turned out were it to have formed with a super-Earth. He created a series of computer models of the Solar System in its current configuration, and into each dropped a different super-Earth between the orbits of Mars and Jupiter to see what would happen. The hypothetical super-Earths were varied in mass between one and 10 times that of Earth, and with initial orbital distances of between 2 AU and 4 AU. Overall, he simulated thousands of these tweaked Solar Systems, and let each run within the computer for the equivalent of 10 million years.

Kane found that the inner, rocky planets were particularly vulnerable to gravitational disruption from a super-Earth companion. For example, with a seven-Earth-mass super-Earth inserted at 2 AU, the orbits of the terrestrial planets quickly become unstable. At 2 AU, the added super-Earth and Mars experience a 2:3 resonance. This means that for every two of the super-Earth's orbits Mars completes exactly three of its own, and so receives a regular gravitational tug. Mars's orbit becomes ever more elliptical as the planet picks up momentum and is rapidly ejected altogether from the Solar System. The increasingly unstable orbit of Mars affects both Venus and Earth, which in turn leads to the ejection of Mercury. And as Venus wanders further out from the Sun, and Earth is nudged inwards, the two experience catastrophic close encounters with each other.

If, instead, the seven-Earth-mass super-Earth is placed at 3.8 AU, it experiences orbital resonances with both Jupiter and Saturn, nudging them both into slightly more elliptical orbits. In this case, the super-Earth is itself thrown out of the Solar System, but not before it has shattered the stability of the inner system and triggered a chaotic orbit in Neptune that leads to Uranus being ejected.

> ***"Mars's orbit becomes ever more elliptical as it picks up momentum and is rapidly ejected altogether from the Solar System"***

Overall, Kane found that the Solar System is largely preserved if a super-Earth were to exist in a narrow range of orbits around 3 AU. But for most of the cases he studied, a super-Earth orbiting between Mars and Jupiter falls into resonance with one or more other planets and acts like a wrecking ball to the stability of the Solar System.

I loved this paper from a gleeful perspective of building toy Solar Systems and watching how catastrophically they break. But there's a deep relevance to this sort of study too, serving both to improve our understanding of the architectures of exoplanetary systems, and to constrain our theories on how they form.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *The Dynamical Consequences of a Super-Earth in the Solar System* by Stephen R Kane
Read it online at: arxiv.org/abs/2302.06641

Sneezes and wheezes of the Butterfly

New imagery shows the nebula puffing 'like a fire-breathing dragon'

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

A series of spectacular images shed new light on the behaviour of NGC 6302, the Butterfly Nebula. Sitting in Scorpius, this object has long been a favourite of both amateur and professional astrophotographers, but the Hubble images presented in this month's paper, covering more than a decade of observations, are the most detailed and interesting yet.

Like all planetary nebulae, the large wings of the Butterfly Nebula are formed from gas expelled from the object's central star, typically a Sun-like star which is entering the last stages of its life. The brightness and dynamism of this particular nebula, in which changes in the gas can be seen in images taken just a year or two apart, suggest that it has a particularly hot and massive central source.

There is certainly plenty of ejected stuff in the system. Carefully puzzling out the geometry of what we're seeing, deriving the three-dimensional shape of the nebula from its two-dimensional image, flattened against the sky like a butterfly pinned to a board, suggests that somewhere between 0.1 and one solar masses of gas make up the nebula we see today.

The next problem is explaining the complexity of the structure itself. Like many planetary nebulae the Butterfly is broadly symmetrical, yet it is anything but simple. The images show what the authors call 'wedges', stretching out from the centre, and between them clumps of material. Several seem to have grown comet-like tails, the result of the action of the powerful winds still flowing from that elusive central source. Images that cover a wider field than Hubble show an extended 'breakout' tail, one of the largest features seen in any planetary nebula, stretching off to the northwest.

Many of these structures are still moving rapidly and, working backwards, the observations suggest that they are the product of a violent period that began 2,300 years ago and lasted perhaps for 1,400 years. It started with the ejection of what is now a long northwestern streamer, which was followed a few hundred years later by the other wedges. Recent activity, in the last couple of hundred years, has further stirred things up. Rather colourfully, the authors compare the multiple ejection events from the unseen central star to 'a series of metaphorical sneezes and a protracted wheeze, akin to a fire-breathing dragon'.

Dragon or not, changes on such a short timescale imply that whatever lurks at the centre of the nebula is evolving quickly. It's possible that there are multiple stars at the centre, with the motions of a binary or even a triple star sculpting the nebula. But what's seen makes most sense if at least one star at the Butterfly's heart is massive, with a luminosity perhaps equivalent to that of a thousand Suns. Such large objects live their lives on fast-forward, and so we are treated to an accelerated view of the end of stellar life as these stars' convulsions produce a nebula of wonderful and confusing complexity.

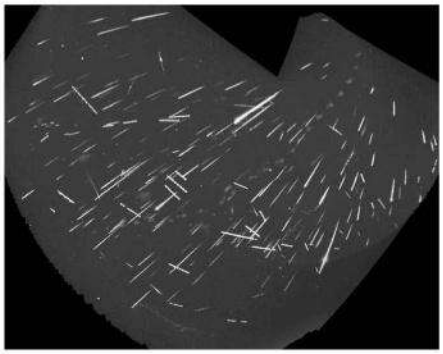
"Changes on such a short timescale imply that whatever lurks at the centre of the nebula is evolving quickly"

Dissecting the Butterfly: researchers took a forensic look at the structures in the Butterfly Nebula's wings

Chris Lintott was reading... *NGC 6302: The Tempestuous Life of a Butterfly* by Bruce Balick et al. **Read it online at: arxiv.org/abs/2303.16439**

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT



▲ **Left: Mary setting up her sky-watching cameras. Top: the fireball she detected in 2021. Bottom: a night's worth of trails from last year's Perseid meteor shower**

On last month's episode of *The Sky at Night*, **Mary McIntyre** explained how basic home CCTV cameras can play a big part in meteor science

When my husband and I set up our first meteor camera back in 2018, we did it not only to learn more about the orbits of the meteor events we observed and captured with our DSLR cameras, but also to see what we were missing while we slept. We loved our first meteor camera so much that we soon set up three more and we now have almost full sky coverage. We had no idea back then just what an important and valuable contribution they would make to so many aspects of meteor and asteroid science.

A meteor is the streak of light we see when a piece of space debris burns up in our atmosphere; a fireball is a meteor that has a magnitude greater than –4.0. Most fireball meteors are asteroid debris, unlike meteor showers which usually originate from comets (the only exception being the Geminids).

The cameras we use to observe meteors are inexpensive CCTV cameras that are capable of capturing low-light images and video. Although basic, they really pack a punch! They're able to detect events down to mag. +6.0 over an approximately 90° field of view. They are connected to a Raspberry Pi computer that is running the free, open-source software from the Global Meteor Network (GMN). The cameras record from dusk until dawn every night and any potential meteor events are saved. The following morning, the software uses a machine learning algorithm to eliminate anything that is not a meteor, then the analysis begins.

The data from multiple cameras is combined and if cameras from different locations have detected the same meteor, it can be triangulated. This means we then have an orbit solution, trajectory, velocity, direction of travel, magnitude and luminous mass estimates for that meteor. In the UK, all of this data is stored in the UK Meteor Network online archive. If a fireball meteoroid was large enough to survive and drop meteorites on the ground, scientists use camera data plus computer modelling to calculate a potential fall zone.

Face-on to a fireball

On 28 February 2021, a mag. –7.9 fireball was seen by thousands of people across the UK and it was captured on several meteor cameras, including ours. The view from our camera was head-on to the fireball so it was impossible to get any trajectory analysis from it. Luckily, other cameras got a much better

MARY MCINTYRE X 3, M-GUCCI/ISTOCK/GETTY IMAGES, SPACEPORT CORNWALL

Mary McIntyre is an outreach astronomer and teacher of astrophotography

view of it (this is why we need lots of cameras!) and the data from six camera networks resulted in the recovery of a pristine carbonaceous chondrite meteorite. This was the first witnessed meteorite fall in the UK for 30 years and it was incredible to be a part of that. Also thanks to meteor camera data, meteorites were recovered from the northern coast of France after the impact of the one-metre diameter asteroid 2023 CX1 on 13 February 2023.

Approximately 65,000 meteorites have been found on Earth, but we only know the original orbits of about 50 of them. Data from the camera networks is giving us that valuable information. Worldwide data from the Global Meteor Network gives us accurate meteor rates and has even resulted in the discovery of new meteor showers. NASA and ESA are also using the data to help keep spacecraft and astronauts safe.

It's incredible how much important science is being done with these little CCTV cameras, and we love being part of this citizen science project. The videos and images from the cameras are awesome for outreach and it's exciting because you never know when the next interesting event will occur.

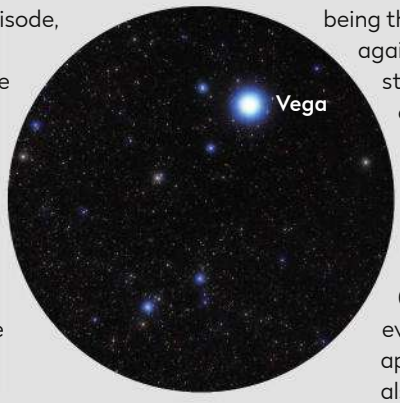
▶ Find Mary's guide to setting up your own meteor camera on our website at bit.ly/meteor-detector

Looking back: The Sky at Night

23 June 1967

In the 23 June 1967 episode, Patrick turned his attention to one of the brightest stars in the night sky: Vega.

Vega is an A-type star with a surface about 4,000° hotter than the Sun, giving it a slightly blue tint. It is just over twice the mass of the Sun and about half-way through its expected one-billion-year main-sequence lifespan.



▲ Vega is visible from the UK throughout the summer months

Its brightness, proximity and high position from northern latitudes mean Vega is one of the most studied stars. In 1872, astronomer Henry Draper chose it as the first star to have its spectra taken (after our Sun). These images showed four of the spectral lines of hydrogen emission, indicating that the star was made of the element. Vega is also very important to astronomers, being the original benchmark against which all other stellar magnitudes were calculated.

So it might be surprising to hear that Vega is actually a variable star, fluctuating by around 0.03 magnitudes every 2.5 hours. Vega's apparent brightness is also changing as the star is getting closer to Earth. Currently, it is around 25 lightyears away, but will get to within about half that distance around 210,000 years from now, and could reach a magnitude of –1.0. Its position in the night sky will appear to change much faster, however, due to the precession of the equinoxes, which causes the northern celestial pole to wobble. Around 12,000 BC, Vega was the pole star and it will reclaim this position in another 13,700 years.

Blast Off: A User's Guide to Space Travel

The Sky at Night team look at the UK's booming space industry as they find out how to build a rocket with one of the companies hoping to be the first to launch from British soil. They also learn how satellites are being tested to withstand the harsh conditions of space, and about their impact on our night skies.

BBC Four, **12 June,** 10pm (first repeat will be on BBC Four, **15 June**, 7pm)
Check www.bbc.co.uk/skyatnight for more up-to-date information

▲ Spaceport Cornwall, one site helping the UK play a key role in the new Space Age

Emails – Letters – Tweets – Facebook – Instagram – Kit questions

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

MESSAGE OF THE MONTH

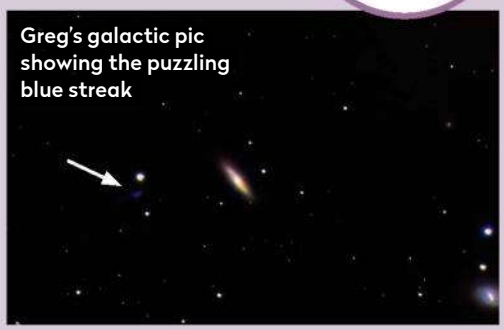
This month's top prize: two Philip's titles

The 'Message of the Month' writer will receive a bundle of two top titles courtesy of astronomy publisher Philip's: Nigel Henbest's *Stargazing 2023* and Robin Scagell's *Guide to the Northern Constellations*

Winner's details will be passed on to Octopus Publishing to fulfil the prize

Mystery object

I took an image of Markarian's Chain on 21 April and after I processed it, I noticed two very prominent, blue-shifted objects. One is galaxy IC 3355; however, there is a bigger and brighter one, near to galaxy NGC 4425, which doesn't appear in any other image I've found. It's clearly visible in my stacked pre-processed image too, indicating that it isn't a processing artefact. It was captured with a ZWO ASI183MC Pro camera through an Evostar ED72 telescope. The best 10 frames of 25x 450-second captures at 111 gain were stacked in DeepSkyStacker and processed with GIMP, StarNet and Topaz DeNoise AI. What do you think it could be?
Greg Sanders via email


Greg's galactic pic showing the puzzling blue streak

We overlaid the paths of asteroids Brixia and Prokne on Greg's unprocessed shot

What an intriguing find, Greg! Stretching the image showed the unidentified blue object is something linear, suggesting that it could be the track of asteroid 521 Brixia, which was in that region at that time and shining at mag. +13.7. However, asteroid 194 Prokne was also around there on that date, shining at mag. +13.2, but can't be seen in your image. Other than that, the track of Brixia looks a decent match. ***– Ed.***

Tweet

Cath Adams
@CathAdams1973 • 20 April
@skyatnightmag Star trails on Thursday 20 April with the added bonus of a meteor too! Venus looks beautiful trailing brightly at the bottom of the image. Taken using iPhone 13 and @NightCapApp

Keep it simple

I've just finished reading Chris Lintott's article, 'Dark matter could be made of black holes' (Cutting Edge, April 2023) in which he reports about tiny black holes being a possible explanation for the glue holding galaxies together. Most of the systems we know, whether small like the atom or large like the Solar System, are held together by forces we're already aware of. Would it be reasonable to assume the same forces are at work here and we're simply looking at a scaled-up version of what we know? It was Ptolemy who said it's a good principle to explain an issue in the simplest possible hypothesis; I also refer to Occam's razor. By the way, I'm a new subscriber. Congratulations on a great magazine – I'm hooked!
Tom Jones, via email

Antique Space Age

Jonathan Powell's article ('The very, very early Space Race", April 2023 issue) got me thinking of the wrongly fictionalised Cyrano de Bergerac, the 17th-century French writer and dramatist (coeval with the fictional Three Musketeers and the real Cardinal Richelieu and English Civil War). He may well have fought over a thousand duels in his youth, but survived to write works of enormous invention, not least *L'Autre Monde: ou Les États et Empires de La Lune*, which contains a description of rocket-powered travel! This was a century when even the most lowly farm labourer could travel the world, whether through choice or by force, but also the first time when theory could be proven through global experiment.
Robin Davie, via email

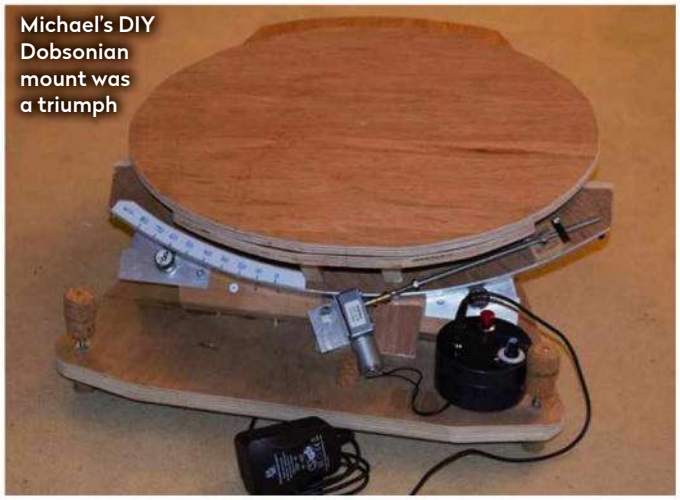
Top Dob job

Thank you very much for putting the Dobsonian equatorial mount DIY project on your website (**bit.ly/dob-platform**). Here is my version of the project, which came in at about £60. I opted for a simpler drive mechanism in the form of an M6 threaded rod, coupled to the platform via an elongated nut. I also calibrated the tracking and added a 'time left' scale, showing how long is left before reset. I was pleasantly surprised by the tracking stability and accuracy of the design over 70–80 minutes of tracking with my 8-inch StellaLyra Dobsonian telescope. My next project will be to build a sturdy home-made altaz fork mount and tripod, so that I can use the platform with a small ED refractor (not yet purchased) for astrophotography.

Michael Gooding, via email

Sad loss

The recent passing of Bob Mizon, the UK coordinator of the BAA's Commission for Dark Skies was very sad and a great loss to the world of astronomy. The work he did in striving to protect our night skies knew no bounds. Bob was a long-time friend and supporter of our ▶



Michael's DIY Dobsonian mount was a triumph

ON FACEBOOK

***The Sky at Night* returned to our screens in April. You got in touch to let us know your thoughts.**

Francisco Javier Lopez Great to have you back. One of my favourite programmes.

Richard Jeffery Glad to have it back on our screens, but half an hour once a month is not enough! I would like to see more of Pete Lawrence and his practical astronomy and astrophotography.

Matthew Terrell Always happy to see them back on the screen.

Andy Huxtable Any chance the BBC will go back to showing *The Sky at Night* on a monthly basis, every month, throughout the year? For 67 years they managed it with Sir Patrick.

Adrian O'Farrell Patrick would not have been happy at that gap in programming. Each and every month is what he would want. No gaps!

Steve Boyle Having to wait three months to see and hear Maggie again is far too long!

SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies

With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

I have a Sky-Watcher 100ED which I use for astrophotography, but find my EQ5 Pro mount too heavy to use, as I only have one good arm. Can you suggest an alternative mount?

PHIL HERBERT

▲ **A permanent pier in your garden will cut down the hassles of setting up each time**

Your existing telescope and equatorial mount are fairly well matched, as the EQ5 Pro has a carrying capacity of 6.5kg for imaging and your 100ED and ASI camera come in comfortably under that weight. A lighter mount will be less suitable for astrophotography and not much easier to handle, so a better solution would be to resolve the handling issue directly to help with your limited mobility.

Perhaps now is the time to consider a permanent mounting in your garden by installing a fixed pier so that the mount and telescope can be permanently set up ready for your use. This would get rid of the need for a polar alignment procedure and will completely remove the hassle of connecting everything up for each imaging session. You'd simply uncover the mount and telescope, turn on, carry out a star alignment and start enjoying your hobby with equipment that you are already acquainted with, and that you can move around unimpeded by tripod legs.

Steve's top tip

What is a Herschel prism?

A Herschel prism, also known as a Herschel wedge, allows you to observe the Sun safely in white light. A wedge-shaped prism mounted in an enclosed diagonal refracts the majority of sunlight (over 95 per cent) that falls onto it away from the observing eyepiece, dissipating the light and heat. The wedge is inclined at a convenient angle so its front face reflects the remaining 5 per cent of sunlight towards the eyepiece. This light is still too bright for direct observing, so it passes through a built-in neutral density (ND) filter first, to reduce its intensity equally at all visible wavelengths and bring it to a safe level.

Steve Richards is a keen astro imager and an astronomy equipment expert

BBC Sky at Night MAGAZINE

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▶ club, the Somerset Levels Stargazers, and often gave talks at our meetings, once inviting the village school to his mobile planetarium. In April 2022, with the help of Bob we held a 10th anniversary event based on dark skies and light pollution; our April 2023 meeting was to have featured Bob once again and although we had the option of cancelling, we decided to hold the meeting as a tribute to him and the subject so close to his heart. We will miss him.
Paul Adamson, Chairman, Somerset Levels Stargazers

Touching tune

It is said that where art and science meet is in the human spirit! In his letter, Bill Smith from Ayr recounted the story of astronaut Laurel Clark and Celtic rock band Runrig (Interactive, April 2023 issue). Their song 'Somewhere' has always been a favourite of mine, but listening to it after reading the story changed the meaning forever. Curious about the inclusion of Laurel's voice at the end of the song, I took to YouTube to search 'Runrig the story' and came across a 10-minute tribute to Runrig and Laurel, which caused a severe lump in the throat. Laurel's wake-up call on the last day of Shuttle Columbia's flight was Runrig's 'Running to the Light'. She was a mission specialist with a love for music and her family and is still flying in our hearts.
George Futers, Peebles

Instagram

matts_world_01 • 21 April

A lovely night at Chard Reservoir, capturing moments like this worth every moment. Just the sounds of nature to keep me company until the wee early hours. Shot with a Fuji X-T2 paired with a 7Artisans 25mm f/1.8 lens and MSM rotator. @bbcskyatnightmag

CORRECTION

In 'How we know Earth isn't flat' (May 2023, page 73), we said Eratosthenes conducted his Sun experiment in Cyrene, Libya; it should have read Syene (modern-day Aswan), Egypt.

SOCIETY IN FOCUS

SIGMA: Moray's Astronomy Club was formed in 2000 with the aim to make astronomy accessible to anyone and everyone, from experienced amateurs to complete novices. Members have a wealth of knowledge and experience, and are always keen to share this with others. We have a growing membership from all areas of Moray and even as far afield as Aberdeen, Inverness and Aviemore.

Club meetings are a mix of in-person and online when it's not possible for a speaker to visit in person – such as a recent talk by a speaker from the Space Telescope Science Institute in Baltimore, USA. We meet at 7:30pm on the first Friday of every month at Lhanbryde Community Centre, and each year we have a full programme of speakers.

We strive to make meetings as diverse and interesting as possible, and regularly hold public observing sessions when members of the public are given guided tours of the night sky. Other outreach activities include delivering talks to local interest groups like schools and the Scouts. In 2022, SIGMA was proud to support the British Astronomical Association's Autumn Weekend in Elgin, attended by guests from the length and breadth of the UK.
Ray Palmer, SIGMA committee member
▶ sigma-astro.co.uk

▲ SIGMA hosted the BAA's Autumn Weekend Meeting in Elgin last year

We pick the best live and virtual astronomy events and resources this month

WHAT'S ON

In Search of the Goddess of the Dawn

Aston University, Birmingham, 27 June, 7:30pm

Andy Ritchie Green, BSC FRAS, who has been photographing aurorae for over 13 years, discusses the mechanics of the aurora, his own experiences and the many legends and myths that surround it. **www.birmingham-astronomy.co.uk**

Confessions of an X-ray Pyromaniac

West Bridgford, Nottinghamshire, 8 June, 7:45pm

Nottingham Astronomical Society presents a lecture by Dr Phil Evans from the University of Leicester, who leads the university's involvement with the Neil Gehrels Swift Observatory. Non-members are welcome. **nottinghamastro.org.uk**

Bad Astronomy in the Movies

Cottingham Civic Centre, East Riding of Yorkshire, 12 June, 7:30pm

Most of us have winced at the shockingly bad science in Hollywood movies. Now Prof Brad Gibson from the University of Hull rounds up some of the worst examples in a talk that will entertain and educate in equal measure. **www.heras.org.uk**

Open mic night

Henry Dixon Hall, Rivenhall End, Essex, 21 June, 7:30pm

In a departure from its normal meetings, North Essex Astronomical Society opens its doors to non-members and invites society members to give 10-minute talks on a topic of their own choosing. £2 members, £3 non-members. **www.northessexastro.co.uk**

Look Up! A Summer Night Sky Tour

Armagh Planetarium, Armagh, daily from 24 June, 1pm

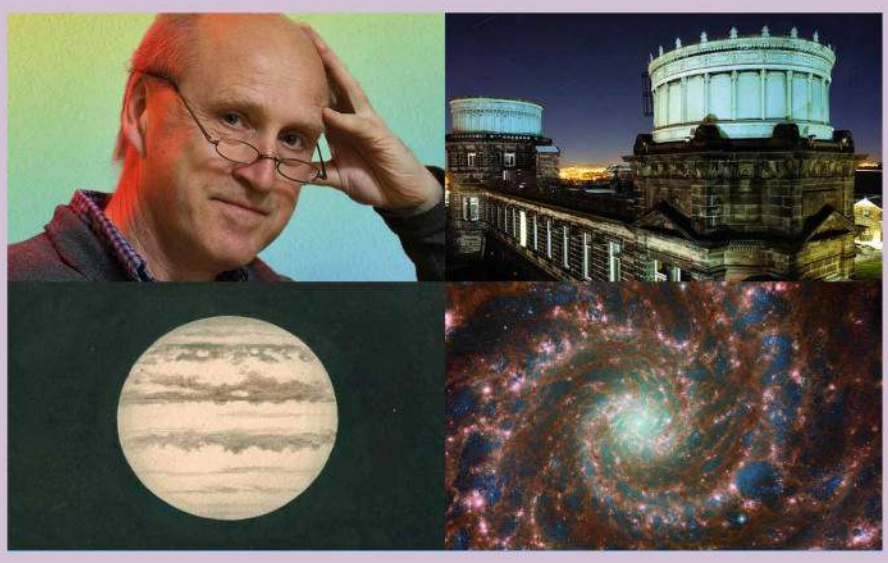
A dome show with a live presenter guiding you through some of the most exciting objects that can be seen in the night sky over Northern Ireland this summer. Adults £9, accompanied under 16s £6.50, family tickets available. **www.armagh.space**

Planetary Protection: What is it and Why is it so Important?

University of Wales Trinity Saint David Campus, King's Road, Swansea, 29 June, 7:15pm

Dr Nik Whitehead from UWTSD discusses the perils and pitfalls of returning samples, equipment – and potentially crew – from Mars and other distant worlds in this free public lecture hosted by Swansea Astronomical Society. Potential members and members from other astronomy societies are welcome. **www.swanastro.org.uk**

PICK OF THE MONTH



▲ Andy Lawrence tells the 200-year story with lots of amazing examples, including Piazzi Smyth's 1856 sketch of Jupiter (bottom left), right through to JWST's images (bottom right)

Making Pictures of the Sky

Augustine United Church, Edinburgh, 2 June, 7:30pm

The Royal Observatory Edinburgh is 200 years old and to mark the occasion the Astronomical Society of Edinburgh hosts this special talk from the University of Edinburgh's Prof Andy Lawrence. A renowned astrophysicist based at the Observatory and honorary president of the society, he'll discuss 200 years of astro imaging – from the earliest experiments with cameras on mountain tops to the latest images from the JWST – and look at the vital role played by the Observatory in some of the most important developments. Free, but booking is essential. For more details, visit **bit.ly/200yearsastroimaging**.

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FIELD OF VIEW

Fighting for the dark side

Battles over a neighbour's floodlight led **Stephen Kirkman** to propose a new law

▲ **The glare from his neighbour's light (left) constantly floods Stephen's garden and renders astronomy all but impossible**

Stephen Kirkman from Wakefield is a longtime amateur astronomer and member of West Yorkshire Astronomical Association

In September 2020, I was pleased to move into my new home, but shortly after settling in I noticed the floodlight on a block of housing association flats next door. An earlier tenant there used to turn it off using the circuit breaker as a light switch. To my dismay, the circuit was switched back on and the whole of my back garden has been floodlit ever since, all night, every night, activated by a dusk-to-dawn light sensor. Night-sky observing is near impossible.

I contacted both the housing association and the local council, at first requesting that the light was switched off. Then I suggested that a new light, shaded, shielded and directed where it needs to be, with a motion sensor, could be installed. The council's response was that as it did not shine into a bedroom there was nothing that could be done. The housing association was similarly unmoved and stated that "that light isn't going anywhere". I deliberated with them for 15 months and even had my local MP write on my behalf. No joy.

That's when I started to look at the legal situation. Ironically, I began with the Rights of Light Act 1959, which was of some help and gave me the idea of legal protection for rights to the dark. I also studied the Clean Neighbourhoods and Environment Act 2005, eventually finding Part 9.102.(2) and the phrase "...artificial light emitted from premises so as to be prejudicial to health or a nuisance". This held a glimmer of hope, but it was put out by Defra's guidance to the act, Statutory Nuisance from Insects and Artificial Light, which says, "Although light pollution might interfere with astronomy, it is not necessarily also a statutory nuisance. The statutory nuisance regime is not an appropriate tool with which to address light pollution per se."

Eventually I concluded there is no specific law recognising a right to darkness from the exterior of a property; the regulations are concerned with the impact on health or the hazard impact to road users. If it were noise or antisocial behaviour, or plants growing across a boundary, there would be a legal case. But not with light. Who would try taking a case like mine to court and risk the cost of thousands of pounds when success is not guaranteed?

So instead I've started a petition on the UK Parliament website called the Right to Dark Law (**bit.ly/dark-law**), calling on legislators to outlaw artificial light trespass from one property to its neighbours. It runs until August and with 10,000 signatures the government will respond to it; with 100,000 it will be considered for debate in Parliament.

There are many groups concerned about light pollution in general, and many homes and businesses are affected by it. If it came to a debate upon the question of whether a home or business owner has a right to a dark night-time environment, it would surely be difficult to claim one does not.

RICHARD J SENIOR X 2

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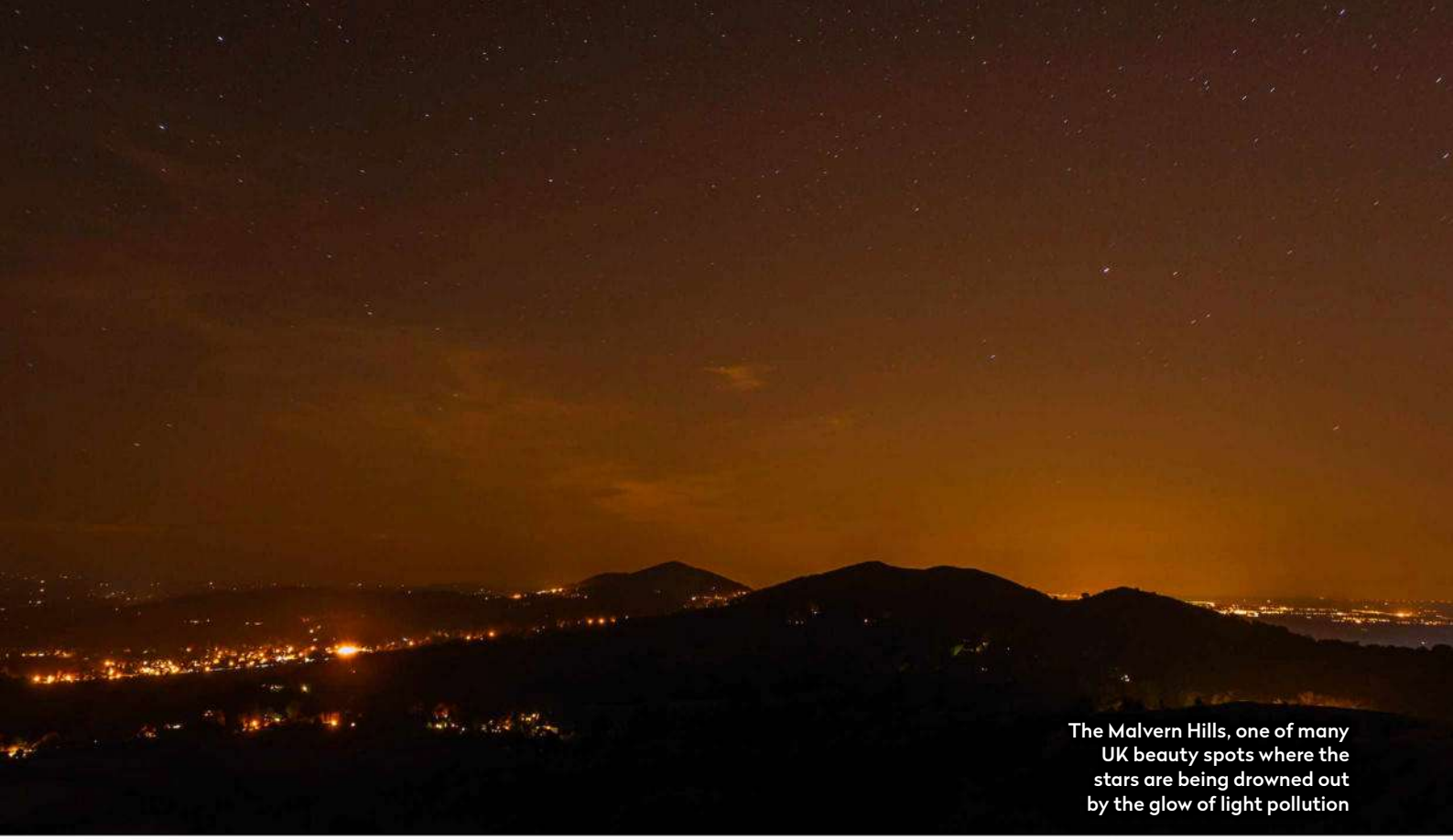
BBC Sky at Night MAGAZINE

Our DISAPPEARING dark skies

Shaoni Bhattacharya looks at what is – and isn't – being done to help ensure everyone can see the stars

A losing battle? The problem is huge but there *are* things we can do to preserve a view of the stars for future generations

NICOELNINO/ISTOCK/GETTY IMAGES



The Malvern Hills, one of many UK beauty spots where the stars are being drowned out by the glow of light pollution

The stars have always been part of human culture. From motifs on Greek pottery to van Gogh's *Starry Night* painting, the connection is evident across the globe. But today, there are few people who get to experience what our forebears saw every night in the sky, researcher Christopher Kyba tells me.

"If you went outside at night you would have had the whole cosmos staring down at you – this really difficult to understand thing," says Kyba. "From my experience with stars, it makes you quite reflective. It changes how you think – this confrontation with *awe*."

The light pollution from humanity's use of lights at night is reducing the number of stars we can see. Year on year it worsens, threatening our connection with the night sky, not to mention the implications for astronomy, wildlife, health, the climate and energy wastage.

To the human eye, the night sky is brightening by about 10 per cent a year, according to a recent study in *Science* by Kyba, a physicist at Ruhr University Bochum, Germany, and his colleagues. At this rate, a child born in a location where 250 stars are visible at night would only be able to view 100 by the time they reach adulthood at 18. "That's a really fast and dramatic change," says Kyba.

He and his colleagues attribute this decrease in star visibility to 'skyglow' – an artificial twilight caused by streetlights, LED signs and residential lighting, scattering off molecules in the atmosphere. While most of this light escapes into space, some of it bounces back down towards Earth.

▼ From billboards to unshielded garden lighting, it all adds to the ever-present skyglow

Measuring the dark

Their research draws on data collected by the ongoing Globe at Night project run by the US National Science Foundation's NOIRLab based in Tuscon, Arizona, which amassed over 51,000 observations made by citizen scientists around the world between 2011 and 2022. Volunteers compared their naked-eye view of the sky at night to a set of star maps, to find what was the faintest star visible. This helped gauge the skyglow, as the brighter the background becomes, the more that faint stars are rendered invisible to the unaided eye.

"What we found is that the charts that people are choosing are rapidly shifting towards the charts that have fewer stars," says Kyba.

In fact, the data showed the fall in the number of stars visible was equivalent to an average increase in sky brightness of 9.6 per cent a year, averaged over their locations – a rate very much larger than the previously measured annual increase of 2.2 per cent. This had been measured by satellites, which in principle can measure skyglow – but with limitations. Currently, Earth-monitoring satellites can't detect wavelengths shorter than 500nm, and yet this type of light scatters more effectively in the

IAN BUTLER PHOTOGRAPHY/ALAMY STOCK PHOTO, OFIRPEREETZ/ISTOCK/GETTY IMAGES, CHRIS WOOD/ALAMY STOCK PHOTO

"When you see the sky is really bright, it's a visual indicator of waste. If you're concerned about the climate, it should concern you"

atmosphere. Modern LED lights also peak in the blue end of the spectrum, between 400nm and 500nm, and our eyes' sensitivity shifts towards shorter wavelengths at night. The team speculates the move towards more energy-efficient LED outdoor lighting during the 2010s may have had an impact.

The caveat here is that Kyba's team are interpreting sky brightness rather than measuring it directly, but it seems certain that people are reporting fewer stars. That should be a concern for everyone.

"When you look outside at night and see the sky is really bright, it's a visual indicator of waste. If you're concerned about climate issues, if you're concerned about energy consumption... then this should concern you," says Kyba. He adds that the increased brightness means humans are shining more light into habitats like wetlands and waterways at night, most likely affecting wildlife.

Light pollution is such an issue that the government in the UK, along with other nations, has begun looking at policies around lighting. Tackling the issue is complex, though, as many people – from individuals to shopkeepers and local authorities – make decisions about light use at night. However, there may be a role for formal restrictions on lighting, says Kyba. For example, the energy crisis caused some places in Germany to require that illuminted signs be turned off after 10pm.

Light-fighting laws

Within the UK, changes in national legislation to combat light pollution have been proposed by a committee known as the All-Party Parliamentary Group for Dark Skies (APPG). This group was set up in January 2020 to protect the UK's night sky by Lord Martin Rees of Ludlow, the Astronomer Royal and ▶

Ten-point plan to protect dark skies

The APPG's proposals to tackle light pollution have been knocked back

1. Strengthen the National Planning Policy Framework, which helps designers constructing new developments to control obtrusive light.

2. Expand the scope of planning permission to include exterior lighting, similar to current rules around installing external advertising.

3. Limit exemptions to Statutory Nuisance Provisions, which give local authorities some power to regulate light that is 'prejudicial to health, or a nuisance'. There are many exemptions and many venues only have to comply if it is 'practicable'.

4. Create a Commission for Dark Skies to oversee compliance.

5. Set lighting standards for brightness and colour – such as the amount of blue light in lighting spectrums – and encourage best practice.

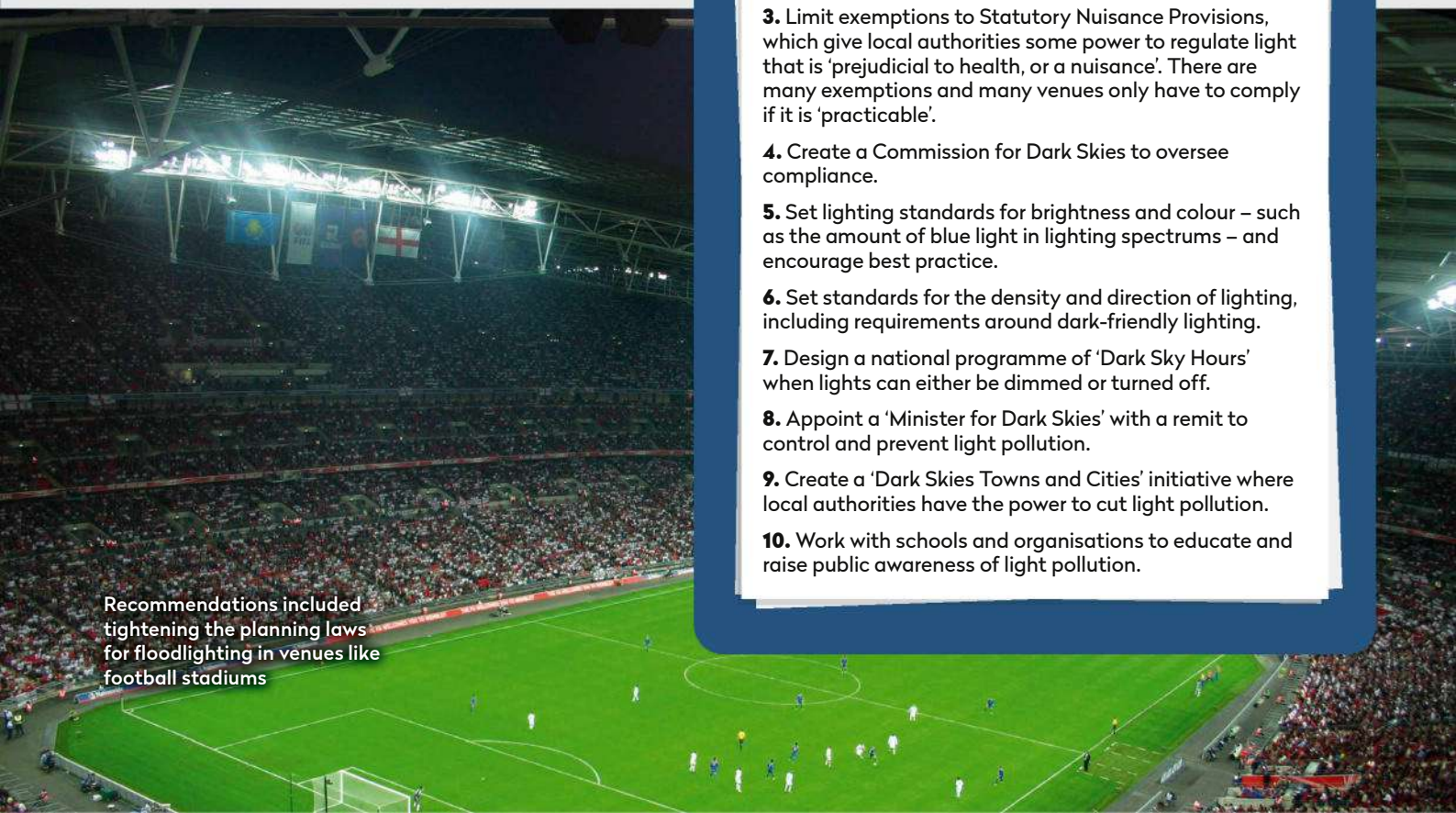
6. Set standards for the density and direction of lighting, including requirements around dark-friendly lighting.

7. Design a national programme of 'Dark Sky Hours' when lights can either be dimmed or turned off.

8. Appoint a 'Minister for Dark Skies' with a remit to control and prevent light pollution.

9. Create a 'Dark Skies Towns and Cities' initiative where local authorities have the power to cut light pollution.

10. Work with schools and organisations to educate and raise public awareness of light pollution.



Recommendations included tightening the planning laws for floodlighting in venues like football stadiums

DARK SKIES APPG, EVERETT COLLECTION INC/ALAMY STOCK PHOTO, NASA

▲ **The Dark Skies All-Party Parliamentary Group was set up to look at all the knock-on effects of light pollution**

▶ a former president of the Royal Society, and Andrew Griffith, MP for Arundel and South Downs – a constituency that includes the South Downs Dark Sky Reserve.

After consultation with over 170 academics, astronomers, national park associations, legal professionals, members of local and national government and lighting professionals, the group published its Ten Dark Sky Policies for Government in December 2020.

"The APPG has a fairly broad remit," says Lord Rees. "Simple energy-saving measures like tightening some of the planning laws about floodlighting stadiums and things of that kind can make them less of a nuisance and avoid brightening the sky unduly."

The committee's policy plan suggests 10 major changes which involve either bolstering existing planning and statutory nuisance laws, 'supercharging' standards for lighting, with legal clout and penalties for non-compliance, as well as encouraging best practice and incentivising dark-sky initiatives.

"The fundamental thing is that [light pollution] is recognised as a pollutant that needs to be controlled under regulation," says Robert Massey, deputy executive director of the Royal Astronomical Society, as currently the UK does not have "hard-nosed legislation" on light pollution.

And the problem, he says, is huge. In the UK, a similar project – the annual star count run by the British countryside charity CPRE – has shown a steady increase in light pollution over the last decade, barring a small dip during the pandemic when many councils, retailers and industrial facilities shut off their lights.

Go-slow government

In February, Massey gave evidence to the Greater London Authority on the potential light pollution from a giant, LED-studded entertainment dome planned at Stratford in London called the MSG Sphere (Las Vegas residents close to a sister venue have warned it will be like 'a Sun on Earth'). It's the

"The last decade showed a steady increase in light pollution, barring a small dip during the pandemic"

What can we do about light pollution?

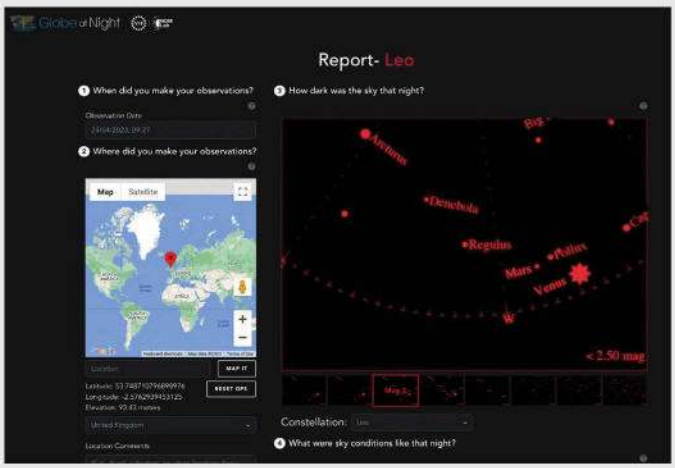
Join the pushback by measuring the sky quality near you

Even small, mindful contributions – such as closing your blinds at night and ensuring outside lights are on a timer and are aiming their light downwards – can help improve light pollution, as can campaigning on projects with harmful impacts. Becoming citizen scientists with the ongoing Globe at Night project helps create the evidence to inform decision-making.

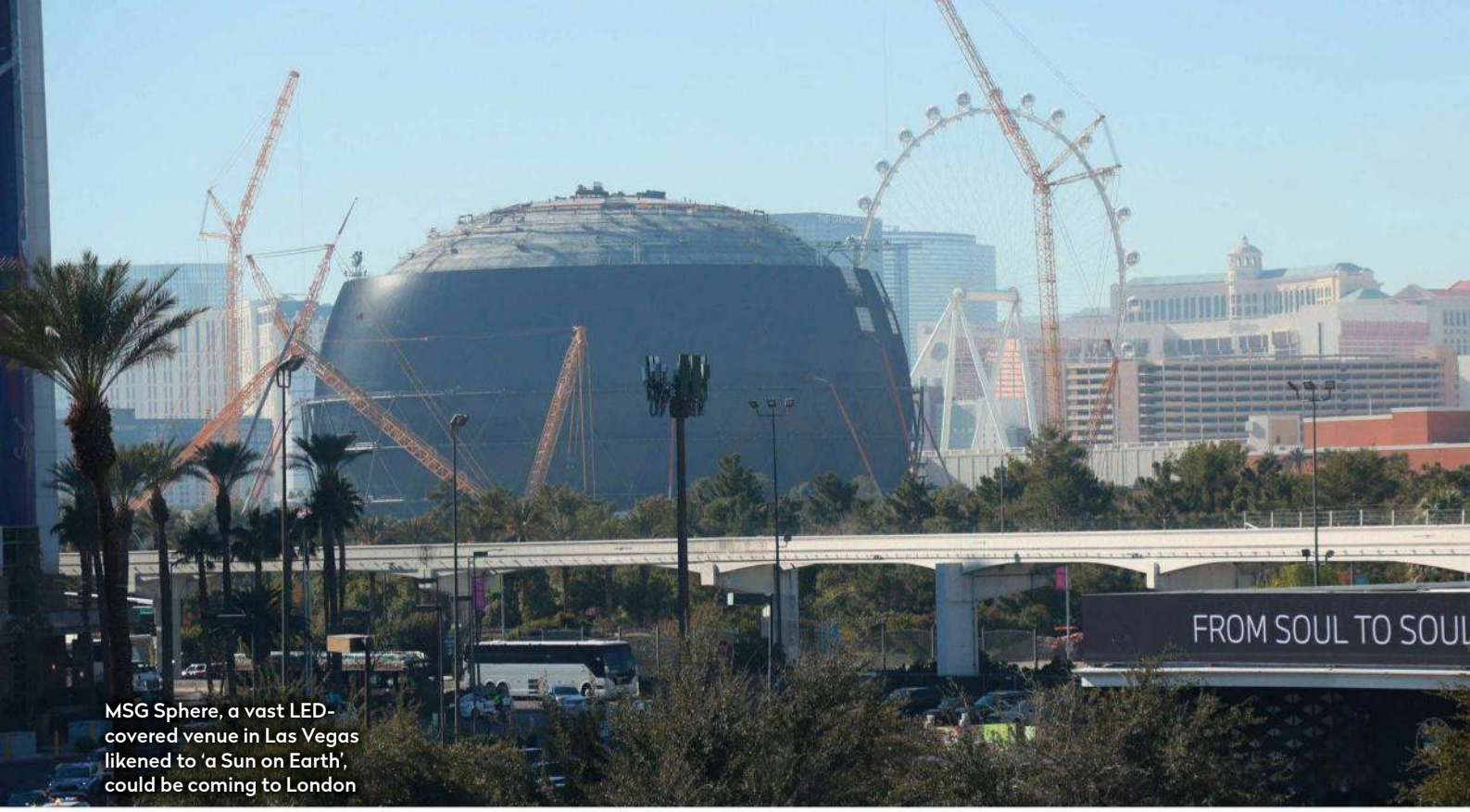
"Your participation makes a big difference to us," says Christopher Kyba. "When you add up 10,000s of subjective feelings, it produces really reliable data."

This is particularly important as many current lighting standards are not scientifically-based. A study on road lighting for drivers and pedestrians published in *Lighting Research & Technology* in 2018, found that "recommendations for the amount of light do not appear to be well-founded in robust empirical evidence, or at least do not tend to reveal the nature of any evidence."

In the UK, participants might look at charts of Orion around January/February, or Cygnus in early autumn. You can find out more at **globeatnight.org**.



▲ **Use Globe at Night's app to report your sky score in real time**

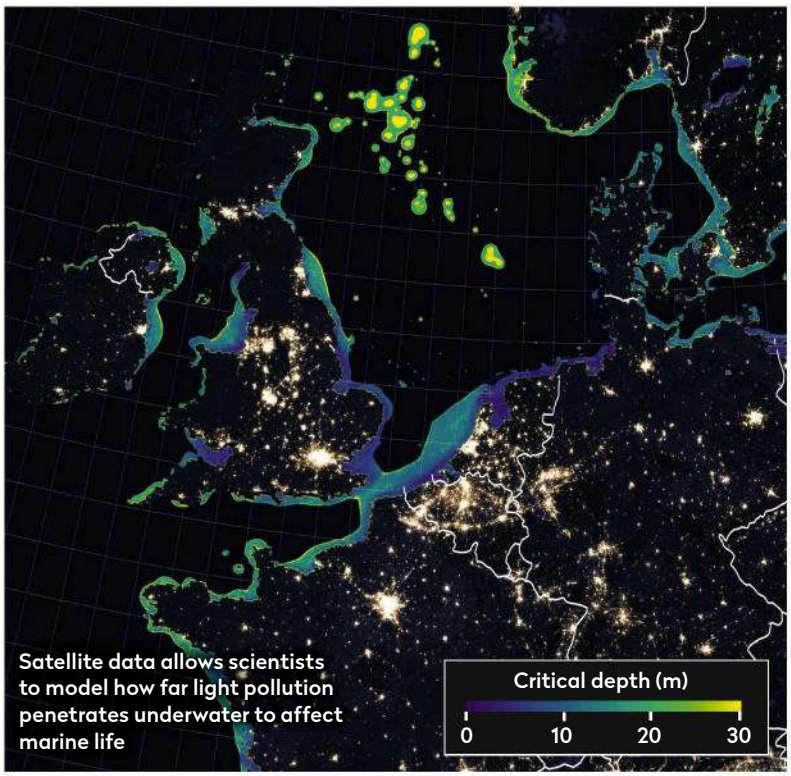


MSG Sphere, a vast LED-covered venue in Las Vegas likened to 'a Sun on Earth', could be coming to London

first time that he has been called for evidence in this way. "The fact that there were discussions on it is welcome," Massey says.

But it appears that the UK Government is not moving on the APPG's plan. "The Government considers the existing measures are sufficient to manage the problems caused by artificial light and there are no current plans to revise them," said Rebecca Pow, Parliamentary Under-Secretary, Department for Environment, Food and Rural Affairs (Defra) on 25 January this year. "Defra also continues to review emerging evidence on the impacts of light pollution on biodiversity."

Shaoni Bhattacharya is a science writer and editor, as well as a short fiction author



Satellite data allows scientists to model how far light pollution penetrates underwater to affect marine life

While they may have to accept that the government has other priorities at the moment, says Lord Rees, "It's our job to raise these issues on the public agenda".

A loss for humanity

The APPG is continuing to listen to the evidence on the effects of light pollution, including the research on insect living patterns and on marine life, which is affected by human-made light as much as 30 kilometres out to sea. But while the impact on astronomy, health and wildlife is important, losing our ability to see stars may underscore a more spiritual loss for humanity.

"When you think about the troubles that we have as a society... worrying about body image and all the rest of this. Well, maybe if we were to have this confrontation with awe several nights of the month, these very individual-focused things would be less of an issue for us," Kyba says.

Most people now live under a constant glow. The only people who can experience the sky as our ancestors did are those who are wealthy enough to visit the few places that still have starry skies, or those who live in areas too poor to afford lighting.

Being unable to see the stars is a fundamental loss, says Lord Rees. "The dark sky is the most universal part of our environment because all humans everywhere in the world throughout history have looked up at the same dark sky and wondered at it and interpreted it in their own way. And so, if young people in urban areas can't see a dark sky, there is a deprivation. You don't have to be an astronomer to feel deprived. I'm not an ornithologist but I would feel deprived if the songbirds disappeared from my garden."

The stars are just as much a part of our precious environment as wildlife and natural habitats, and so protecting our night sky is a matter for everyone.

Sally Ride led the way in the West as the first US female in space, flying on board Space Shuttle Challenger in 1983

The FIRST WOMEN of space

Ezzy Pearson reveals how Valentina Tereshkova and Sally Ride blazed the trail for womankind

Sixty years ago this June, a Soviet factory worker with a passion for parachuting became the first woman to fly in space. Twenty years and two days later, half a world away a tennis-playing astrophysicist followed suit to become the first American woman in space. This month, we take a look back at the flights of Valentina Tereshkova and Sally Ride – two individuals who forged the way for women in space. Yet while one's flight remained something of a one-off with little lasting effect on her nation's space programme, the other's was the start of a step-change in outlook that continues to this day.

Born on 6 March 1937, Valentina Tereshkova was the daughter of a tractor driver who died during World War II. Upon reaching adulthood, Tereshkova worked in a textile factory, continuing to study in her spare time. Unlike most future astronauts, she did not spend her childhood dreaming of space. Instead, it was a different passion that decided her path – parachuting. She began the hobby in 1959 after seeing an advertisement for a local club, and by the early '60s she was jumping competitively.

At the time, the Soviet Union dominated the Space Race. It had successfully put the first man, Yuri Gagarin, into space, but there were concerns that the US might launch a female astronaut just so that they could claim that 'first'. ▶

NASA

First female: Valentina Tereshkova's patriotic back story and parachuting prowess won her the launch pad spot

The textile factory worker underwent months of rigorous training

Her suit was a specially tailored version of the one worn by Yuri Gagarin

▶ "We cannot allow that the first woman in space will be American," Nikolai Kamanin, director of cosmonaut training, wrote in his diary, and soon began seeking out potential candidates.

Previous cosmonauts had been drawn from the air force, but with no female pilots, Kamanin instead looked for experienced parachutists. They would need to be under 30, as well as under 5 foot 7 inches (1.7m) in order to fit into the single-person Vostok crew capsules. Tereshkova was one of five women who fitted the criteria and underwent cosmonaut training. During this, the women were put through tests to ensure their bodies could cope with the physical demands of spaceflight, were taught to fly MiG jets and instructed on the workings of their spacecraft.

Soviets surge ahead

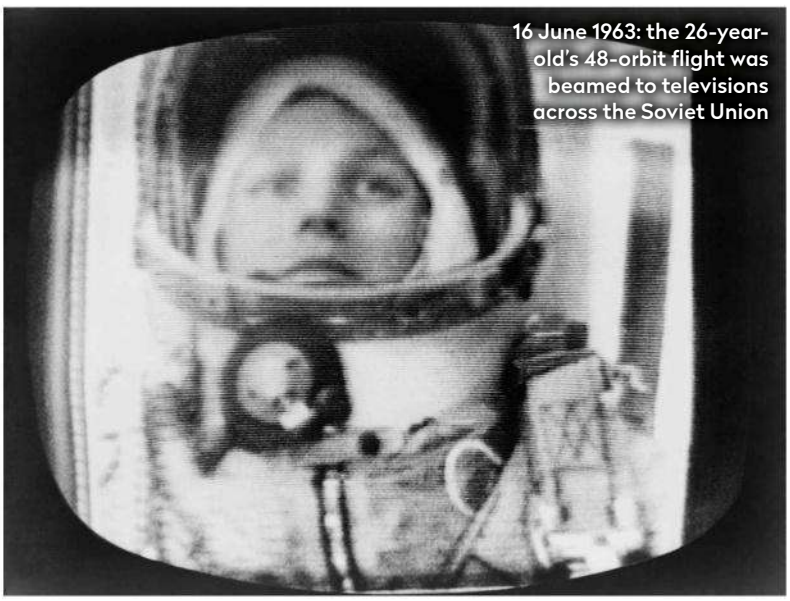
Once training was complete, the question became which of the five women would fly. As it had been with Gagarin before her, it was Tereshkova's origin story that gained her her seat on Vostok 6. She was the embodiment of the Communist ideal: the daughter of a farmer who had died for his nation, who had educated herself, proving anyone – man or woman – could rise through hard graft. It was for this that Kamanin referred to Tereshkova as "Gagarin in a skirt".

Her flight launched on 16 June 1963 with the exuberant yell of "Hey sky, take off your hat. I'm on my way!".

Part of her mission was to look out of the window and take photos of the atmosphere, which would be used to study particles in the upper stratosphere.

"I see the horizon," she said looking out from the cockpit. "A light blue, a beautiful band. This is the Earth. How beautiful it is! All goes well."

Despite her upbeat words, the cramped Vostok capsule meant Tereshkova was uncomfortable for most of the flight. A combination of zero gravity and



16 June 1963: the 26-year-old's 48-orbit flight was beamed to televisions across the Soviet Union

Locals gather to meet her as she awaits pick-up after parachuting to the ground in Kazakhstan

GETTY X 5, EVERETT COLLECTION INC/ALAMY STOCK PHOTO, NASA/MIKE FOSSUM

Cosmonaut women

Tereshkova got there first, but few Russian women followed in her footsteps

After the flight, Tereshkova's career became centred around touring the globe, and she was the most frequently requested cosmonaut of the entire Soviet spaceflight programme. However, her success meant she never flew again. When Gagarin died in 1968 in a plane crash, the Soviet Union realised it couldn't risk losing another celebrity, and she was grounded.

In 1963, she married fellow astronaut Andriyan Nikolayev. Their daughter, Elena, was the subject of much curiosity, as she was the first person born to two people who had been in space. They divorced in 1982.

By the time NASA advertised for the 1978 astronaut class, the first intake to include women, the Soviets had yet to put another woman in space. Not wanting to be outdone again after Apollo's triumph, the next class of cosmonauts included nine women along with four men. Tereshkova herself was allowed to requalify as a cosmonaut. In August 1982, fellow class member Svetlana Savitskaya travelled to the Salyut 7 space station, just beating Sally Ride to be the second woman in space. However, she was the only woman from the class to fly in space and, to date, in total only five of Russia's cosmonauts have been women.

Politically active throughout her life, Tereshkova has held many offices since retiring from spaceflight and currently sits in the Russian parliament, the Duma.

Tereshkova, pictured here in 2010, followed her space career with a life in politics

▲ On a promotional tour with Yuri Gagarin in 1963. After Gagarin's death, Tereshkova – an invaluable asset to the Soviet state – was prohibited from flying again

unpalatable food meant she often felt ill. Then, after she vomited she found out that the ground crew had forgotten to include toothpaste with the toothbrush they'd packed for her.

Despite this, Tereshkova handled the craft well. On her first orbit, she passed within five kilometres of Vostok 5, which had launched just two days before her, the manoeuvre testing several procedures that would allow future spacecraft to dock together. She returned to Earth three days and 48 orbits later, narrowly avoiding disaster when she noticed that the Vostok's guidance programme was set to ascend from orbit, rather than descend. As with all Vostok missions, she ejected before impact and parachuted to the ground, ending her space journey using the very skill that had got her there.

In the weeks and months that followed, Tereshkova became a celebrity, with several parades in her honour. Behind the scenes, though, there was a very different sentiment. While there had been plans for the other female cosmonauts to fly, the nation's lead spacecraft designer Sergei Korolev put a stop to them, citing the fact that one of the candidates already had a family.

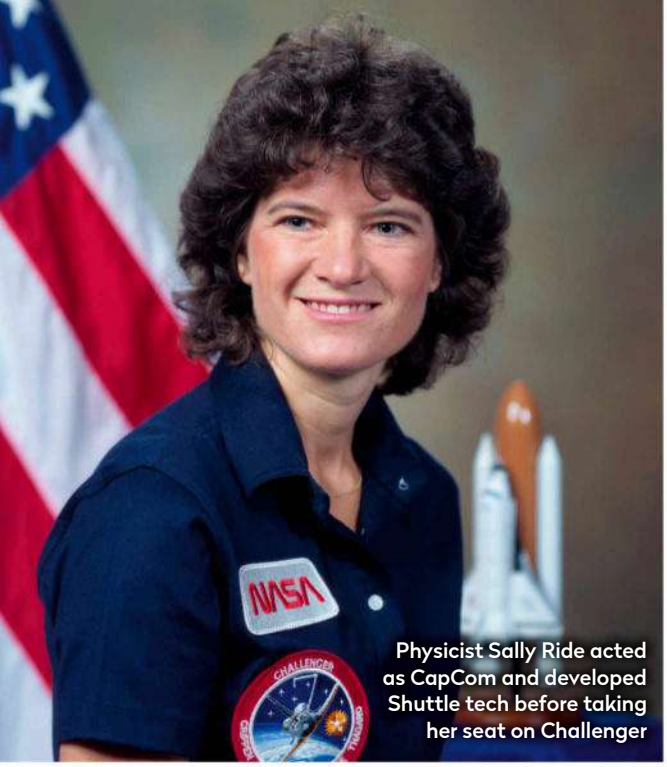
"They forbade me from flying, despite all my protests and arguments," Tereshkova said years later. "After being once in space, I was keen to go back there. But it didn't happen."

Though the female cosmonauts disagreed with the decision, and wrote to the central party committee, their opinions were ignored. The Soviets had claimed their 'first'.

Meanwhile in America...

NASA could well have beaten them to the punch, however. In 1959, William Randolph Lovelace, the physician in charge of determining who was physically suited to spaceflight, had been curious about how the female body would respond to his tests. He'd secretly called in several women, 13 of whom passed the first stages. He went public with the results, hoping to garner support for further tests, which would require access to military facilities. Instead, many at NASA, including several of the male astronauts, pushed back against the idea. Rather than ban women outright, NASA insisted that candidates needed jet pilot experience which could only be gained in the military – and which *did* ban women from flying.

The tacit ban would remain in place until 1977, when NASA was selecting its first astronaut class in eight years. Apollo was long over and the agency ▶



Physicist Sally Ride acted as CapCom and developed Shuttle tech before taking her seat on Challenger

Ride (left) was part of NASA's 1978 astronaut intake, the first to include women

The first US woman in space, and at 32 the youngest US astronaut, poses with the rest of the Challenger crew in June 1983

The mission specialist deployed satellites and conducted experiments during the six-day flight

▶ was looking to crew its new project, the Space Shuttle. With a capacity of eight people, the programme would require many new astronauts. Equal rights for women and for people of colour had become far more prominent in the West since the last astronaut intake, and so the requirements were broadened to accommodate a more diverse range of people.

To push the applicant call to as many people as possible, NASA advertised on TV, radio and in newspapers. It was reading the latter that brought the initiative to the attention of PhD student Sally Ride. A highly active person, Ride had found her first love in the world of tennis. Her prowess at the sport netted her several scholarships to study physics at university and, despite training for hours every day, she excelled academically. She eventually went to Stanford University for her PhD. It was when she was about to graduate and wondering what direction to take her life that Ride spotted the advert.

"The moment I saw that, I knew that that's what I wanted to do... I wanted to apply to the astronaut corps and see whether NASA would take me and see whether I could have the opportunity to go on that adventure," Ride said in a 2006 interview at the US Astronaut Hall of Fame.

The USA plays catch-up

In all, 8,079 people applied and just 35 were chosen. Among them were one Asian-American man, three African-American men and six women, one of whom was Ride. After completing basic training in 1978, Ride worked within NASA on the Shuttle's Remote Manipulator System, Canadarm, as well as acting as CapCom on two missions, being the link between ground control and the astronauts in orbit.

The first six crewed flights of the Shuttle were flown with smaller crews from earlier astronaut classes, but by the seventh flight, STS-7, it was time for the class of 1978 to take their seats, and one of them would be a woman. The mission would require Canadarm, with which Ride was well-experienced, but it was Ride's ability to get along with and work alongside almost anyone that led to her being selected to be the first American woman in space.

NASA had seen the impact being 'the first' could have on an astronaut's life with Neil Armstrong, so officials asked if Ride was willing to accept that fame. She agreed, but in truth Ride had little comprehension of how intense the attention would be. While Tereshkova had been somewhat protected by the Soviet Union's policy of not publicising

NASA X 5, DOMINIC HART

In it for the long Ride

Sally Ride remained dedicated to space long after her barrier-breaking mission

After her flight on STS-7, Ride stayed with NASA and flew a second Shuttle mission, STS-41-G, in October 1984. She was joined on board by Kathy Sullivan, making it the first space mission with two women. It also made Ride the first US woman to fly in space twice and Sullivan the first US woman to perform a spacewalk, though cosmonaut Svetlana Savitskaya had claimed both of these world firsts a few months earlier.

Ride was scheduled for a third flight, but this was cancelled following the Challenger disaster. Instead, she was appointed to the commission investigating the accident, leading to a more managerial role at NASA, planning the agency's future.

She left NASA in 1987, taking various university professorial posts, although she continued to work with NASA on outreach programmes. She set up Sally Ride Science to encourage children, particularly girls, into taking up science.

Ride dedicated much of her later life to inspiring children of all backgrounds to study science

Both presidents Clinton and Obama offered her the role of NASA administrator, but she turned them down.

Ride married fellow astronaut candidate Steven Hawley, but later divorced. After her death on 23 July 2012, her family revealed (with Ride's consent) that she had been in relationships with both men and women throughout her life and had been with female partner Tam O'Shaughnessy for 27 years, making her the first known gay astronaut.

Ride was a skilled operator of the Shuttle's robotic arm, seen here retrieving the SPAS-01 science platform

Ezzy Pearson is *BBC Sky at Night Magazine*'s features editor. Her book *Robots in Space* is available through History Press

missions until they were under way, Ride was under the microscope from the moment her assignment was announced.

"Really the only bad moments in our training involved the press," Ride said in an interview with feminist Gloria Steinem. "Whereas NASA appeared to be very enlightened about flying women astronauts, the press didn't appear to be. Without a doubt, I think the worst question that I've gotten was whether I cried when we got malfunctions in the simulator."

She endured the questions and on 18 June 1983 the first American woman headed to space on board the Challenger Space Shuttle.

"The view of Earth is absolutely spectacular, and the feeling of looking back and seeing your planet as a planet is just an amazing feeling," said Ride in the 2006 interview. "It's a totally different perspective, and it makes you appreciate, actually, how fragile our existence is."

A flair for spaceflight

Ride thrived in orbit. Unlike many new astronauts, she didn't experience any form of space nausea – a little ironic given the crew was meant to test new space-sickness medication, which she couldn't do. Instead, she dedicated herself to the main task of releasing three new satellites. Two of these were communications satellites, while the third was the Shuttle Pallet Satellite SPAS-01, which would test the formation of alloys in microgravity. During the deployment procedure, she manoeuvred the robotic arm into the shape of a '7' to celebrate the flight.

After a six-day mission, the Shuttle headed home. Bad weather forced it to divert its landing to Edwards Air Force Base in California, but it was one of only a few hiccups in an otherwise flawless mission. Ride's flight had proved women could not just handle spaceflight but excel at it.

In the years since, there has been a global push to increase female engagement with space and science. Astronaut classes from NASA, the European Space Agency and other nations have included an ever-increasing number of female candidates – many of whom cite both Ride and Tereshkova as inspirations. Just over 70 women have flown in space, out of a total of around 600 people, but the number is growing as more and more women are being assigned to missions. With NASA's Artemis programme in full swing, it won't be long until one of them takes "one giant leap for womankind".

COSMOLOGY CRASH COURSE

What happened BEFORE the Big Bang?

Govert Schilling answers your questions on cosmology's most confusing concepts

ILLUSTRATION

It's the question that always comes up when thinking about the origin of the Universe: what came before? And if there was no 'before', what was the cause of the Big Bang in the first place?

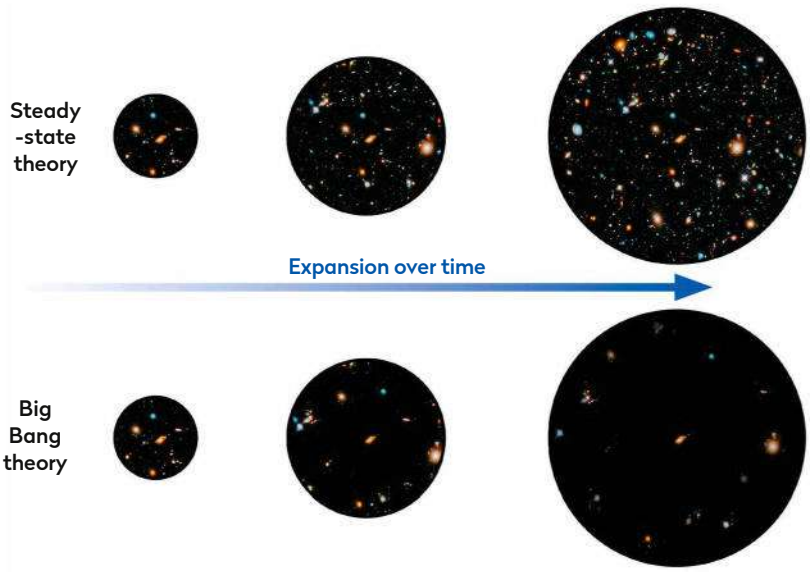
Until a few centuries ago, the answer was easy: some eternal deity set everything in motion. Even Isaac Newton believed that God created the Universe, some 6,000 years ago. Later, many scientists, including young Albert Einstein, assumed the Universe itself to be eternal and everlasting. But when cosmic expansion was discovered, Belgian cosmologist (and Jesuit priest) Georges Lemaître realised there must have been a beginning – a scientific version of Genesis, so to speak.

Not that everyone immediately agreed. Well into the 1960s, Fred Hoyle's steady-state theory was quite popular among iconoclastic scientists as well as lay people. Hoyle accepted cosmic expansion, but he didn't believe in the Big Bang. Instead, he assumed that a slow, continuous creation of new matter could keep the average density and the general properties of the Universe constant over time.

The 1964 discovery of the cosmic microwave background was the major nail in the coffin of the steady-state theory. Ever since, supporting evidence for the Big Bang origin of our Universe has accumulated to a point where there's hardly any doubt left.

Still, no one has the final answer to the question in the title of this instalment of our Cosmology Crash Course. Most scientists simply ignore it, as it seems to be too hard a nut to crack. In fact, when astronomers talk about the Big Bang, they usually do not refer to the very beginning of the Universe (time zero), but to the incredibly hot and compact state of the Universe in the first couple of minutes of its existence.

To some extent, this is because no one has a real clue about the true nature of time, let alone about the beginning of time. British physicist Julian Barbour, for one, has argued that time doesn't even exist, except as an illusion in our minds. According to others (including Stephen Hawking), time came into

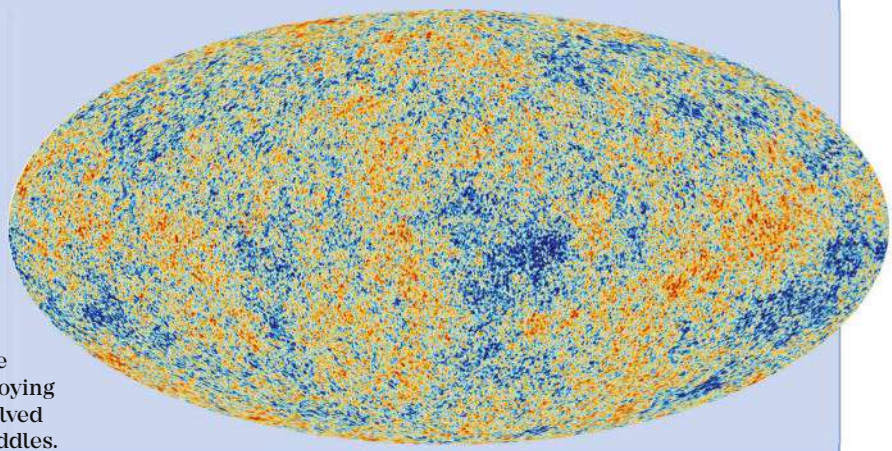


▲ **Popular in the 1950s, steady-state theory claimed matter is continuously created as the Universe expands, a theory overtaken by the Big Bang idea that density drops as galaxies move away from one another**

ESA AND THE PLANCK COLLABORATION, FLAVIO COELHO/ISTOCK/GETTY IMAGES, ARTISTOSTELES/WIKIPEDIA, CLAUS LUNAU/SCIENCE PHOTO LIBRARY, VICTOR DE SCHWANBERG/SCIENCE PHOTO LIBRARY/ ISTOCK/GETTY IMAGES

Universal riddles

Countless cosmic conundrums remain to be solved



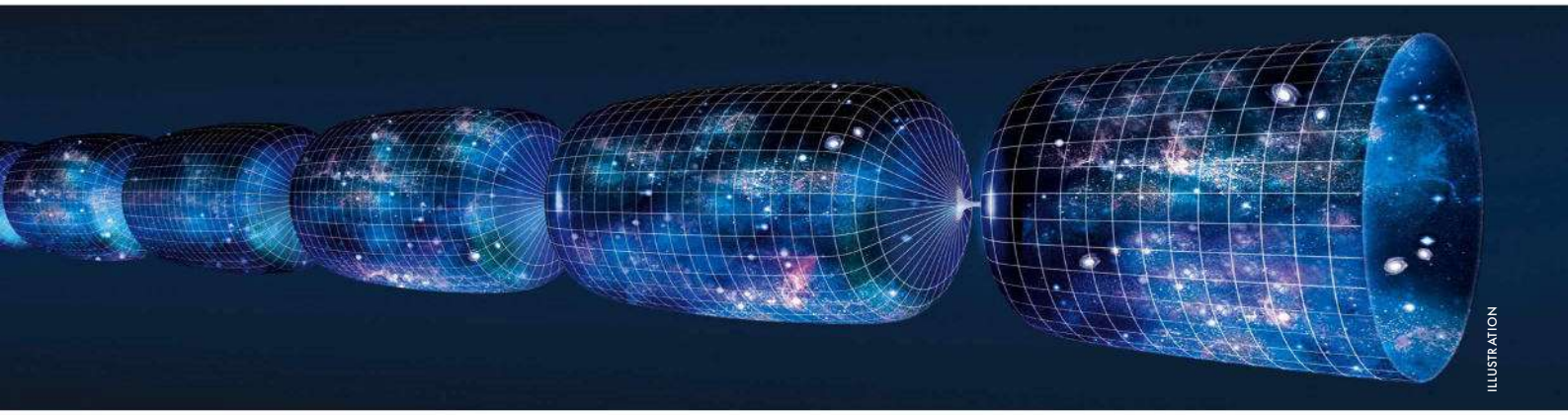
▲ Despite glimpses like Planck's study of the cosmic microwave background, much of the Universe remains unfathomable

Over the past decades, scientists have unravelled a lot of cosmological mysteries. In particular, detailed observations of the cosmic microwave background by the European Space Agency's Planck mission, as well as large-scale surveys of the three-dimensional distribution of galaxies, provided so much information about the early stages and the later evolution of the Universe as to warrant the use of the phrase 'precision cosmology'.

Nevertheless, astronomers are left with an annoying number of unsolved cosmological riddles.

Apart from the fact that no one knows what (if anything) happened before the Big Bang, there's no consensus on the hypothesis of cosmological inflation – an extremely early and brief phase of exponential expansion without which a number of properties of the Universe, like its homogeneity and lack of large-scale curvature, would remain unexplained. Moreover, although cosmologists know the Universe contains 68.5 per cent of dark energy, 26.6 per cent of dark matter and a mere 4.9 per cent of 'normal' matter (atomic nuclei), the true nature of both dark energy and dark matter is a mystery.

Finally, we don't know about the long-term future of the Universe, and no one knows why the particles and forces in nature have the masses, charges, strengths and other properties they do.



ILLUSTRATION

▲ Yo-yo diet: an oscilliating Universe starts with a bang, contracts to a crunch then starts anew, expanding and contracting over and over

existence together with the Universe, rendering the whole concept of the word 'before' meaningless. Asking what happened before the Big Bang would be like asking what lies north of the North Pole, or what distance is shorter than zero.

Alternative theories

Then again, we simply don't know whether or not there was time before the Big Bang. According to the once-popular idea of the cyclic (or oscillatory) Universe, the current expansion of space could one day revert into a contraction, and the resulting Big Crunch could bounce into a new Big Bang, starting the next cycle of an eternal sequence.

It's just one of many hypotheses in which our Universe is not unique, but part of a possibly infinite multiverse, one way or another. And if the multiverse is also infinite in time, we're back to the idea that everything has existed forever, conveniently circumnavigating the nagging question of a beginning.

ILLUSTRATION

▲ Nothing special: ours may be one of an infinite number of parallel universes

Finally, South African physicist Neil Turok thinks the Big Bang not only spawned our Universe, but also an anti-Universe, composed of antimatter and running backward in time. Again, an intriguing idea, but there's also no chance of confirmation (or rejection!) via observations.

In the end, we have to admit we're ignorant about the true beginning of the Universe. And even if we lean towards an eternal multiverse with no real beginning at all, we don't know why there is something (or, more to the point, why there is everything) instead of nothing. Who knows what answers a 22nd-century Cosmology Crash Course may give?

Govert Schilling's book *The Elephant in the Universe* is published by Harvard University Press

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BBC Sky at Night MAGAZINE

16-PAGE CENTRE PULLOUT

The Sky Guide

JUNE 2023

BRIGHT SUMMER PLANETARIES

Take our Deep-Sky Tour of the bright and beautiful planetary nebulae on show this month

DAWN PATROL

On the lookout for summer's noctilucent clouds

BUMP INTO THE BEEHIVE

Mars and Venus meet the wonderful M44 cluster

PETE LAWRENCE

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four

Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- Venus reaches eastern elongation
- Discover the ancient Gutenberg crater
- Moon and Venus together in daylight

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

JUNE HIGHLIGHTS

Your guide to the night sky this month

All month

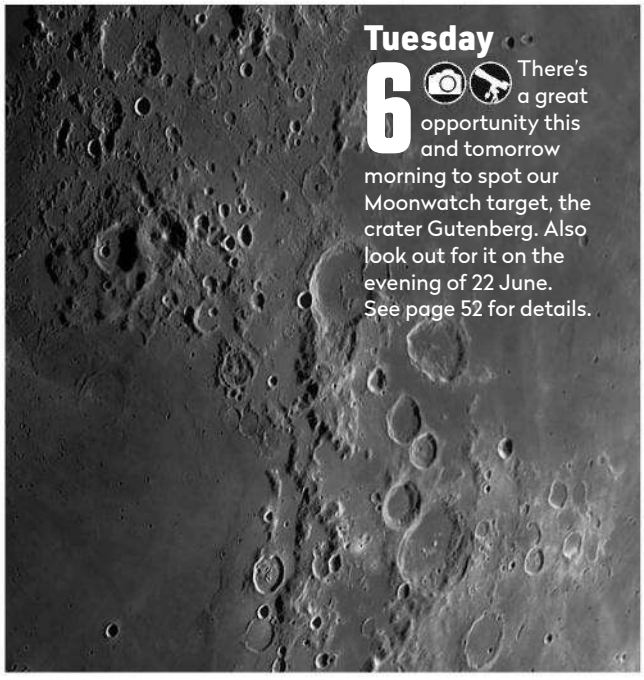
June and July are the best months for spotting elusive noctilucent clouds (see page 46).

Friday 2

Compromised by twilight, mag. +1.6 Mars passes in front of the Beehive Cluster, M44, this evening.

Saturday 3

The mag. +1.0 red supergiant Antares (Alpha (α) Scorpii) appears one apparent lunar diameter south of the full Moon's southern limb at 23:15 BST (22:15 UT).



Tuesday 6

There's a great opportunity this and tomorrow morning to spot our Moonwatch target, the crater Gutenberg. Also look out for it on the evening of 22 June. See page 52 for details.

Tuesday 13

Venus is north of the Beehive Cluster, M44, this evening. The best chance to see the pairing is just before Venus sets.

Wednesday 14

A 15%-lit waning crescent Moon sits 0.6° to the north of Jupiter in the early hours. See whether you can observe the planet using binoculars after the Sun has risen.

Saturday ▶ 17

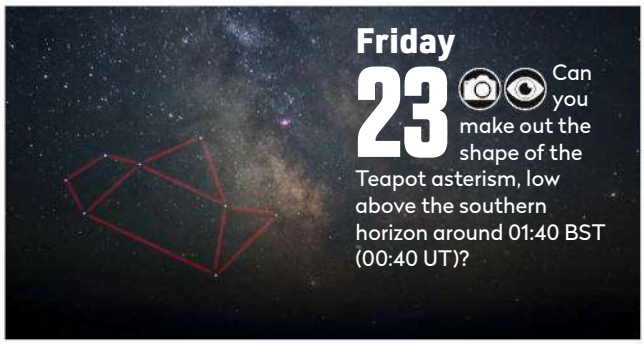
The earliest sunrise of 2023 occurs today, when the Sun rises at 04:38 BST (03:38 UT) (time from the centre of the UK), just a few seconds earlier than on the surrounding days.

Sunday 18

Although there's not much real darkness at this time of year, bright patterns such as the Summer Triangle asterism stand out very well.

Family stargazing

It's that time of year when the night times shrink to a minimum, making it tricky for youngsters to do much astronomy. One fun project is to keep a look out for noctilucent (night-shining) clouds. These may be seen low above the northwest horizon 90–120 minutes after sunset or a similar time before sunrise, low above the northeast horizon. They appear to glow against the deep twilight and often have a delicate, net-like appearance. Although not ideal in terms of timing, they are easy to observe without any equipment (see page 46). **www.bbc.co.uk/cbeebies/shows/stargazing**



Friday 23

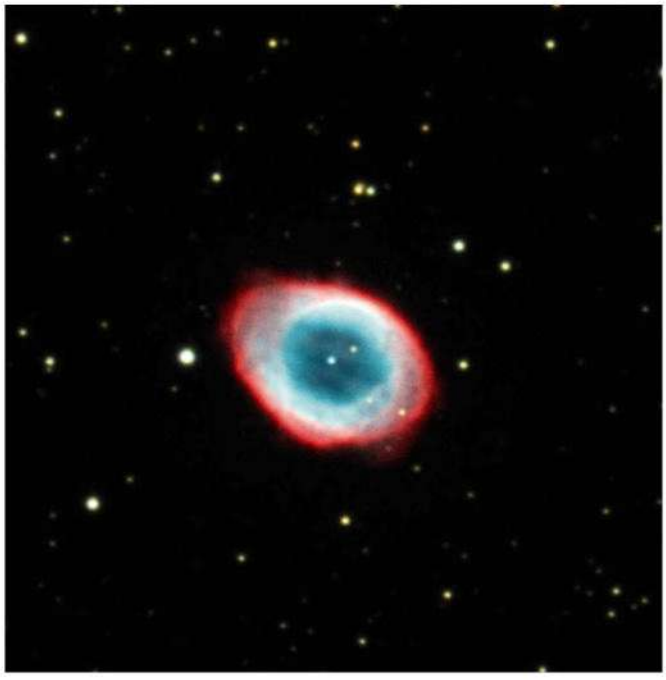
Can you make out the shape of the Teapot asterism, low above the southern horizon around 01:40 BST (00:40 UT)?

PETE LAWRENCE X 6, M57: CHRISTOPH KALTSEIS/CCDGUIDE.COM

Sunday
4 Venus reaches greatest eastern elongation, appearing separated from the Sun by 45.4° in the evening sky.

Monday
5 A look at the northeast limb of the Moon this morning should show the parallel line clair-obscur effect known as the Zeno Steps, near crater Zeno.

Thursday ▶
8 As the Moon moves out of the way, this is a great time to try our Deep-Sky Tour on page 56. This month, we're hunting bright summer planetary nebulae.



Friday
16 Minor planet 20 Massalia reaches opposition at 10th magnitude in Ophiuchus.

Wednesday
21 Today at 15:58 BST (14:58 UT) is the Northern Hemisphere's summer solstice, the point at which the Sun reaches its most northerly position in the sky.

Thursday
22 Today a 16%-lit waxing crescent Moon rises around 09:00 BST (08:00 UT), 4.2° from mag. –4.3 Venus. Mars is also 3.4° south of the crescent Moon.

Friday
30 Mag. –4.3 Venus is 3.6° from mag. +1.7 Mars, low on the west-northwest horizon shortly after sunset.

A 91%-lit waxing gibbous Moon is 5° west of Antares (Alpha (α) Scorpii) this evening.

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal Time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY
If you're new to astronomy, you'll find two essential reads on our website. Visit **bit.ly/10_easylessons** for our 10-step guide to getting started and **bit.ly/buy_scope** for advice on choosing a scope

DON'T MISS

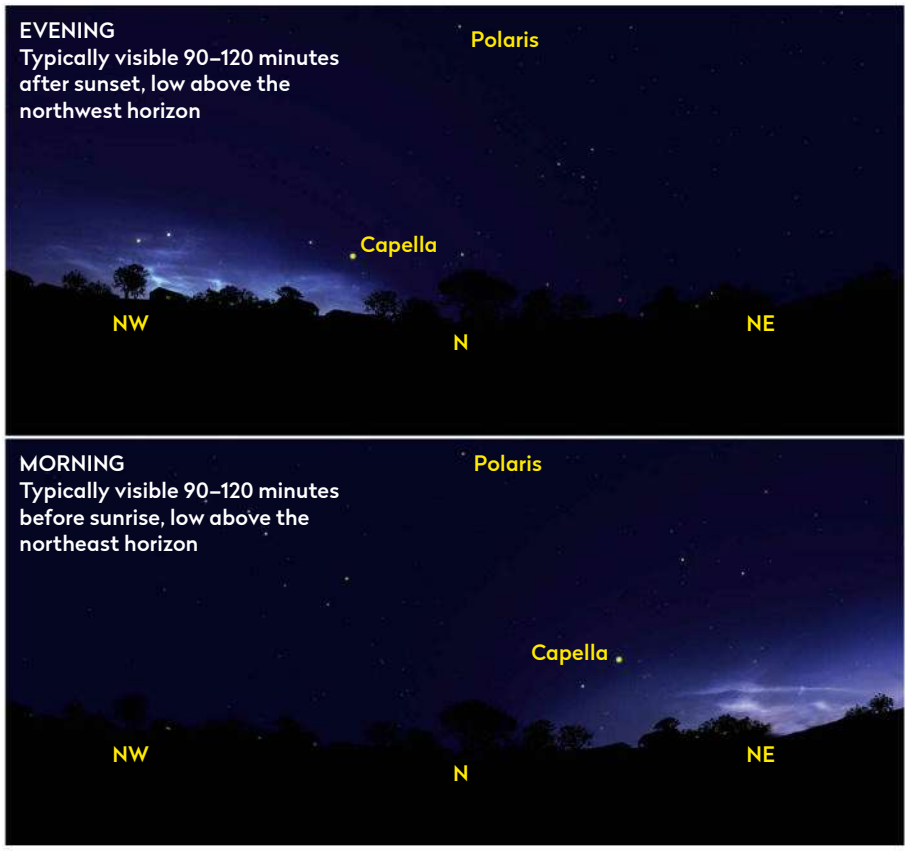
Noctilucent cloud season

BEST TIME TO SEE: All month, 90–120 minutes after sunset or a similar time before sunrise

June and July are the best months to try to spot elusive noctilucent, or night-shining, clouds (NLCs). These are high-altitude ice sheet clouds that form in a narrow layer within the atmospheric region known as the mesosphere. In order for them to appear, there has to be some form of seeding agent in this layer and there has to be super-cooled water vapour present.

The theory as to how water vapour gets up into the mesosphere is complex. Once there, a super-cooled situation occurs when the temperature of the mesosphere dips below a certain threshold, which counterintuitively occurs in the summer months. NLCs can also be seen from the Southern Hemisphere during its summer period. Introduce a tiny speck of dust into the super-cooled vapour and a tiny ice crystal will form around it. In the case of NLCs, the seeding dust mostly comes from meteoroids vaporising in Earth's atmosphere – basically meteor dust.

Being so high, at around 80km up, NLCs are still illuminated by the Sun despite it being dark for us on the ground. As a result, they become visible in the deep, summer twilight. Typically, they are visible 90–120 minutes after sunset, low above the northwest horizon, or a similar time before sunrise, low above the northeast horizon. An extensive amount of NLC ice sheet may cause a display to persist throughout the night, passing from the northwest through north and ending in the northeast as dawn breaks. What you're seeing when this happens is sunlight following the position of the Sun below the horizon.



▲ **Typical NLC displays may be seen all night long, moving from the northwest, through north and ending low above the northeast horizon where they can be seen before sunrise**

NLCs are often quoted as a low-altitude phenomenon from the southern half of the UK, gaining more altitude from the north of the country. This is largely true, and if your northwest-north-northeast horizon isn't particularly flat, it's really easy to miss them. However, NLCs have been reported at much higher altitudes, especially at the start and end of the visibility period, so it pays to remain vigilant. At high altitudes under darkening or lightening twilight, they can take on an appearance that resembles high-altitude cirrus. Make a note in your observing log if you're not sure whether the NLCs you've seen are cirrus.

NLCs aren't particularly limited by light pollution or artificially bright skies. This makes them an ideal target during the period when traditional night-time astronomy takes something of a backseat due to the lack of proper darkness.

At their great height, NLCs reflect sunlight and appear to shine in deep twilight, unlike lower, regular clouds that remain in shadow and appear dark

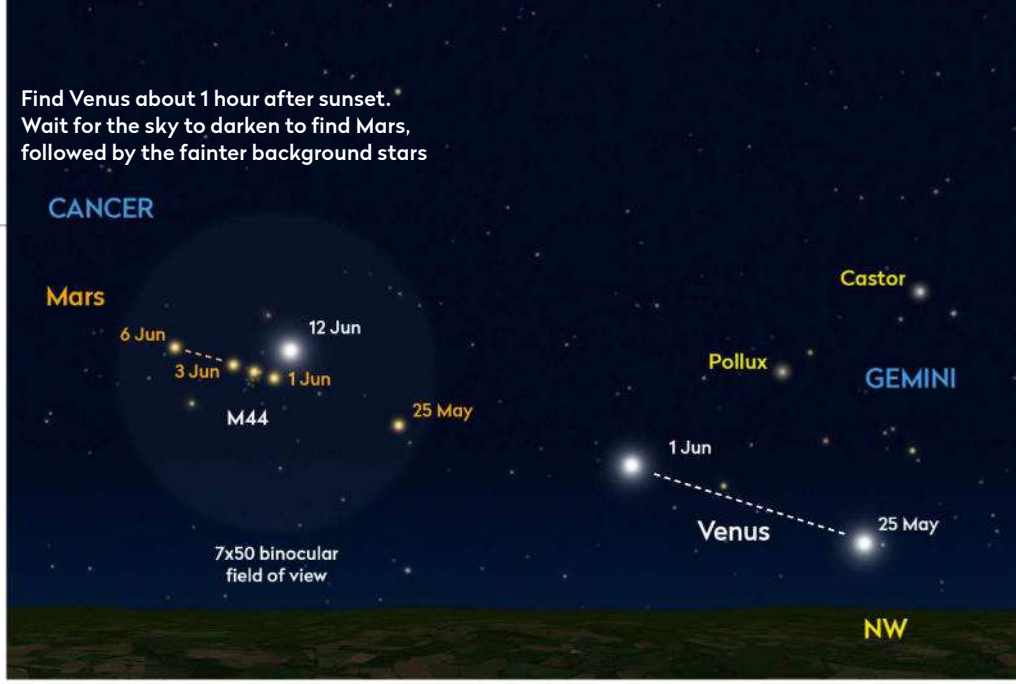
ALL PICTURES: PETE LAWRENCE

Mars and the Beehive

BEST TIME TO SEE: 1–3 June Mars and M44; 12–14 June Venus and M44

The Beehive open cluster, M44, is a wonderful deep-sky object visible in the winter and spring sky. Its position is less than ideal during June, but despite this, during 2023 it poses an observing challenge as it's visited by the two main planets, Mars and Venus.

The encounter with Mars is right at the start of June, arguably when M44 is easiest to see. On the evening of 1 June, as Venus gets very low and the evening twilight begins to darken enough to show stars, use binoculars to find Mars. It's 10° to the left and slightly up from Venus, pink-orange in colour and shines at mag. +1.6. On this evening, it is located on the western edge of M44. The brighter cluster stars should be visible using binoculars given a flat west-northwest horizon. Similarly, a telescope with a camera attached, pointed at Mars, should be able to deliver the cluster as well.



▲ **Both Mars and Venus appear to pass the Beehive Cluster, M44, this month. Mars appears in front of the cluster on the evening of 2 June and it's Venus's turn on 12–14 June**

A line-of-sight alignment means that Mars appears within the cluster on the evening of 2 June and slightly to the east of it on the evening of 3 June. It's not the easiest sight, but a rewarding challenge given clear skies. Timings will vary across the UK, so a good rule of thumb is to wait until Venus is at just over 2° altitude. If using binoculars with a 5° field, the horizon should just be showing at the bottom of the field of view when Venus is centred.

The Venus–M44 encounter occurs on 12–14 June, Venus passing just north of the cluster. Bright twilight and low altitude will make this a tough observation. If you managed to see Mars and M44 earlier in the month, then you're already prepared for just how difficult this can be.

Mars and Venus

BEST TIME TO SEE: 21, 22 June then 29 June–2 July

The encounter between Mars and the Beehive, followed by Venus and the Beehive (above), suggests that both planets are in the same part of the sky after sunset. Shining at mag. –4.3, Venus reaches greatest eastern elongation on 4 June, but despite its prominence in the evening sky over the past weeks, it is dropping in altitude after sunset. At that brightness it's still easy to see, though, and a good pointer to the much dimmer planet Mars, which shines at mag. +1.7 towards the end of June.

On the evening of 21 June, Venus and Mars will be joined by a slender 12%-lit waxing crescent Moon, a lovely evening scene to mark the day of the June solstice. On 22 June, the Moon will have increased in phase to 19% and sits further to the east of both planets. Venus and Mars will appear slightly closer on this date, appearing separated by 4.5° on 21 June and 4.3° on 22 June.

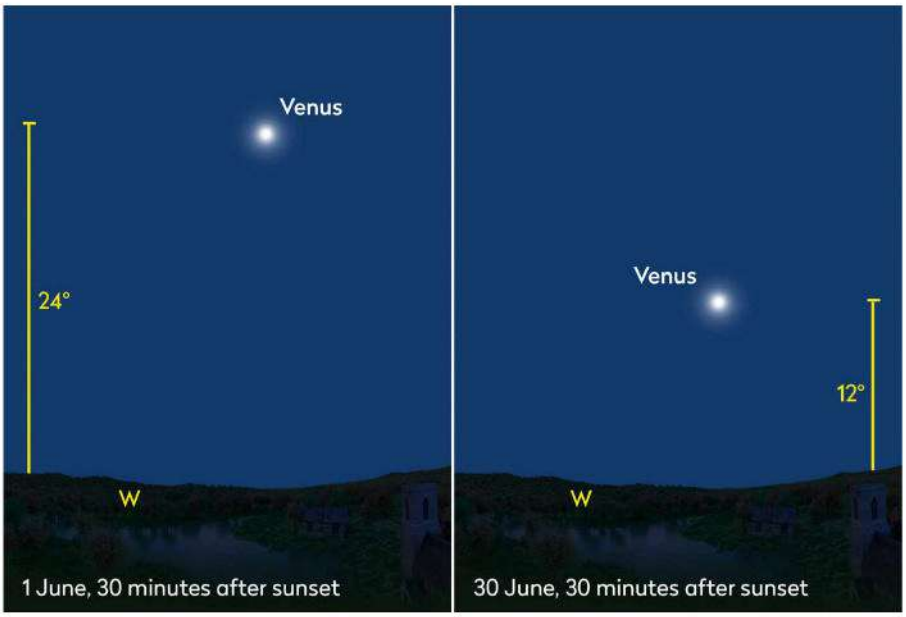
▲ **A low-altitude meeting between bright Venus, harder-to-see Mars and a waxing crescent Moon takes place over two evenings around the summer solstice**

Both planets continue to approach one another to reach a minimum separation of 3.6° between 29 June and 2 July. This makes them an ideal binocular target, but a flat west-northwest horizon is essential. Look out for Regulus (Alpha (α) Leonis) to the left of Mars, appearing fractionally brighter than the planet at mag. +1.3.

PICK OF THE MONTH

Venus

Best time to see: 1 June, from 1 hour after sunset
Altitude: 19°
Location: Gemini
Direction: West-northwest
Features: Phase, subtle surface markings
Recommended equipment: 75mm or larger



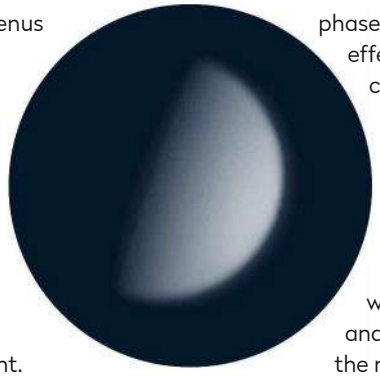
▲ **Venus's altitude after sunset drops rapidly this month**

Venus is literally at a turning point in the evening sky this month, reaching a position known as greatest eastern elongation – when it appears furthest from the Sun on the sky's dome – on 4 June, when it will be separated from the Sun by 45.4°. Despite such an excellent separation, Venus's position is starting to deteriorate as seen from the UK, with the planet appearing lower in the sky after sunset.

As a consequence, on 1 June Venus sets 3.5 hours after the Sun, but by the end of the month this figure will have dropped to just two hours. At mag. –4.3, Venus appears to pass across the northern extremes of the Beehive Cluster, M44, on the evening of 12 and 13 June. This will be a very tricky thing to observe due to the bright evening twilight, which is always present while Venus is above the horizon.

A 12%-lit waxing crescent Moon sits near Venus on the evening of 21 June. On this date, mag. +1.7 Mars will appear close by too. The two planets are 3.6° apart at the end of June, but Mars will be hard to spot against bright twilight.

On the evening of 4 June, Venus will reach dichotomy, appearing half-lit. But does it look 50%-lit to you? The phase anomaly or Schröter effect is a phenomenon caused by Venus's thick atmosphere, which affects the visual timing of dichotomy. Through a telescope, Venus appears to reach 50%-lit a few days early when in the evening sky and a few days late when in the morning sky. Take a look for yourself, making as many phase estimates as you can from late May through to mid-June.

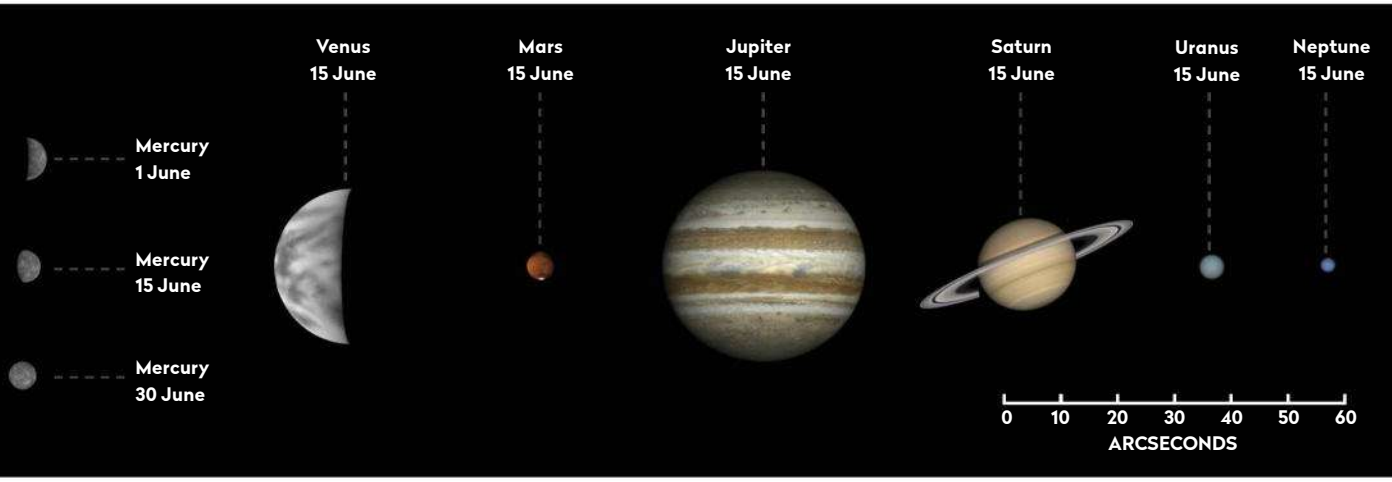


▲ **Venus's 50% phase is predicted for 4 June, but its atmosphere makes this appear earlier**

PETE LAWRENCE X 2

The planets in June

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



Mercury

Best time to see: 15 June, 30 minutes before sunrise
Altitude: 2° (extremely low)
Location: Taurus
Direction: East-northeast

After a disappointing show last month, Mercury fares only marginally better during June. It's a morning planet, but being located south of the ecliptic plane, fails to gather much altitude before sunrise. On the plus side, it is brightening and by mid-month, shining at mag. –0.6, Mercury rises 50 minutes before the Sun. On 16 June, a 4%-lit waning crescent Moon sits 7.4° west and slightly north of the planet (above and to the right from the UK). On 17 June, the now 1%-lit waning crescent Moon lies 5.4° to the northeast of Mercury (to the left from the UK). As the month progresses, Mercury appears brighter but it closes in on the Sun's position, becoming lost in the glare during the last third of June.

Mars

Best time to see: 1 June, from midnight BST (23:00 UT)
Altitude: 9° (low)
Location: Cancer
Direction: West-northwest

An evening planet, mag. +1.6 Mars appears to cross the Beehive Cluster, M44, between 1 and 3 June, but low altitude and bright twilight make this tricky to see from the UK. The best strategy is to look for mag. –4.2 Venus low above the northwest horizon as the sky starts to get dark; Mars and the cluster are to the left and up a bit from brilliant Venus, as seen from the UK. Mars and Venus themselves appear to converge throughout June, joined by a waxing crescent Moon on the evenings of 21 and 22 June. On 28 June, Mars and Venus appear 3.6° apart. By the end of the month, Mars shines at mag. +1.7, appearing 4 arcseconds across through the eyepiece, which is too small for significant detail to be seen.

Jupiter

Best time to see: 30 June, 03:00 BST (02:00 UT)
Altitude: 10°
Location: Aries
Direction: East

Jupiter is a morning object, but the planet never manages to gain much height before the morning twilight engulfs it. A 15%-lit waning crescent Moon sits 0.6° to the north of the planet at 06:00 BST (05:00 UT) on 14 June. The Sun will be up at this time, but if you can find the Moon, this is a good opportunity to try to spot Jupiter under daylight conditions.

Saturn

Best time to see: 30 June, 02:20 BST (01:20 UT)
Altitude: 16°
Location: Aquarius
Direction: Southeast

Saturn's situation is slowly improving, but it remains less than ideally placed this month. This is due to the planet having a low altitude and the dawn twilight making the sky too bright to give a decent view. A 58%-lit waning gibbous Moon sits 4° below mag. +0.7 Saturn on the morning of 10 June.

Uranus

Not visible

Neptune

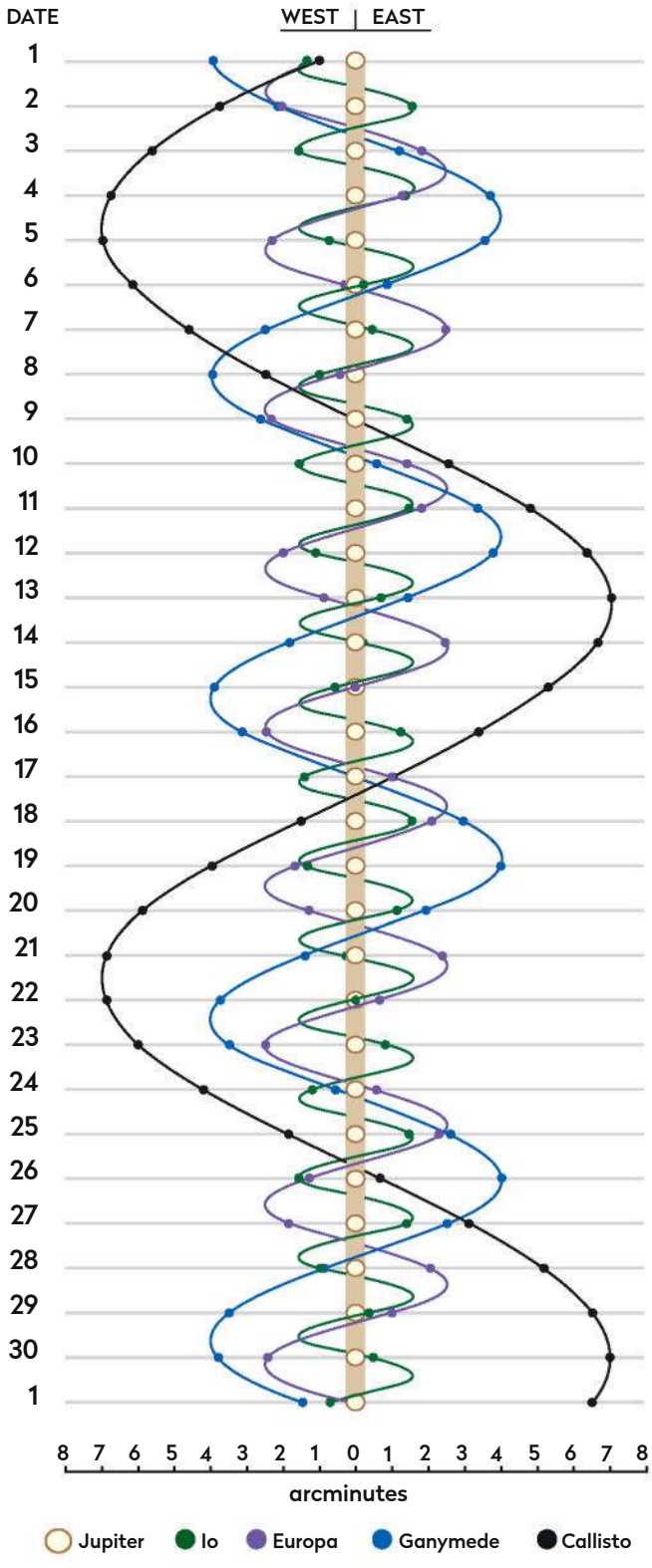
Not visible

Neptune is a morning object that's tricky to view, lost as it is in the dawn twilight.

MORE **ONLINE**
Print out observing forms for recording planetary events

JUPITER'S MOONS: JUNE

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically over the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT).



THE NIGHT SKY – JUNE

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Circlet — ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER
- COMPASS AND FIELD OF VIEW
- MILKY WAY

CHART: PETE LAWRENCE

When to use this chart

1 June at 01:00 BST
15 June at 00:00 BST
30 June at 23:00 BST

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.

Sunrise/sunset in June*

Date	Sunrise	Sunset
1 Jun 2023	04:48 BST	21:28 BST
11 Jun 2023	04:42 BST	21:38 BST
21 Jun 2023	04:41 BST	21:43 BST
01 Jul 2023	04:46 BST	21:42 BST

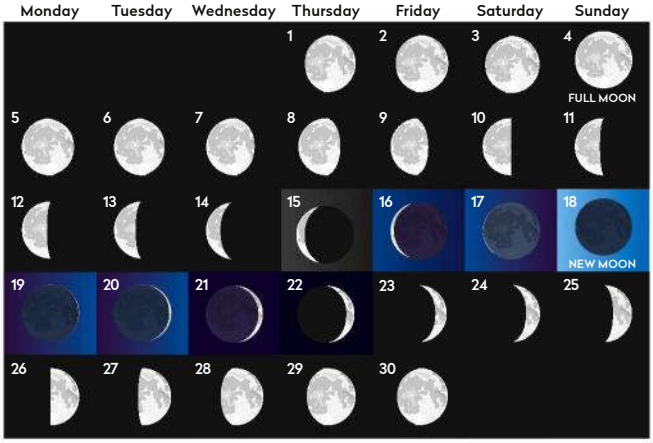
Moonrise in June*

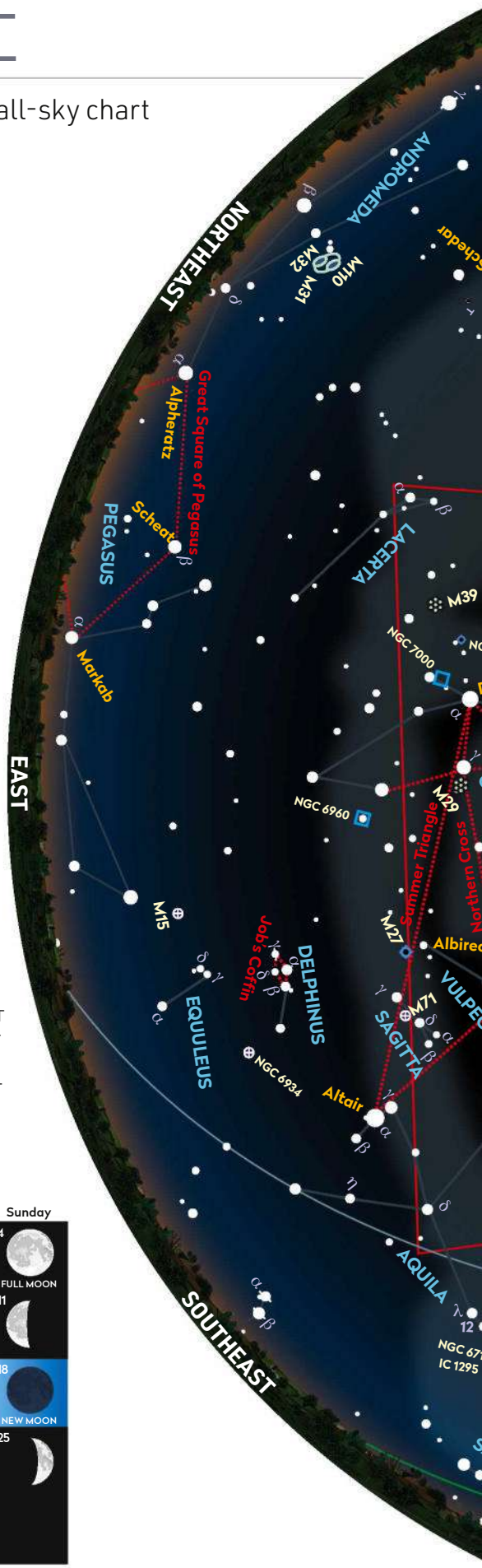
Moonrise times

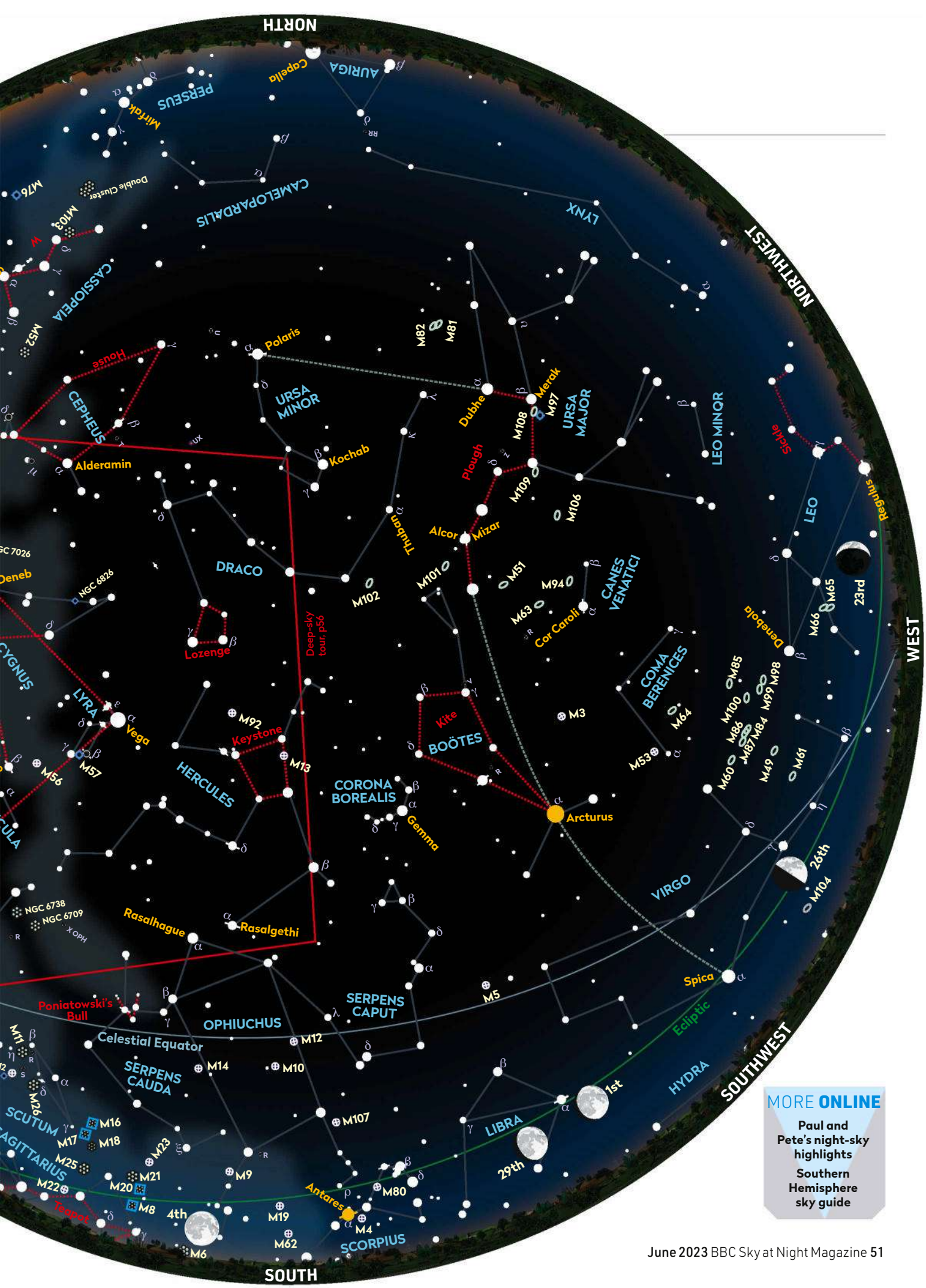
1 Jun 2023, 18:26 BST	17 Jun 2023, 03:34 BST
5 Jun 2023, --:-- BST	21 Jun 2023, 07:16 BST
9 Jun 2023, 01:39 BST	25 Jun 2023, 12:12 BST
13 Jun 2023, 02:26 BST	29 Jun 2023, 17:23 BST

*Times correct for the centre of the UK

Lunar phases in June







MORE **ONLINE**

Paul and Pete's night-sky highlights

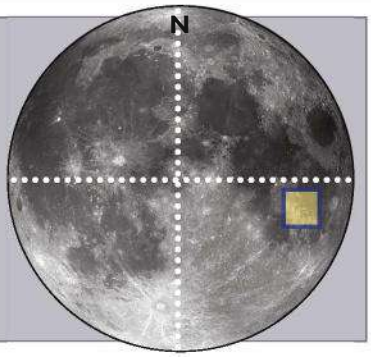
Southern Hemisphere sky guide

MOONWATCH

June's top lunar feature to observe

Gutenberg

Type: Crater
Size: 75km
Longitude/latitude: 41.2° E, 8.6° S
Age: Older than 3.9 billion years
Best time to see: Five days after new Moon (22 June) or four days after full Moon (6–7 June)
Minimum equipment: 50mm refractor



Gutenberg is an ancient crater located on the western shore of 600 x 500km **Mare Fecunditatis**, the Sea of Fertility. It's the northernmost of a rag-tag collection of similar ringed formations which adorn this section of Fecunditatis's edge, sharing the attribute of being the largest member of the group with **Colombo** 240km to the southeast; both Gutenberg and Colombo are 75km in diameter.

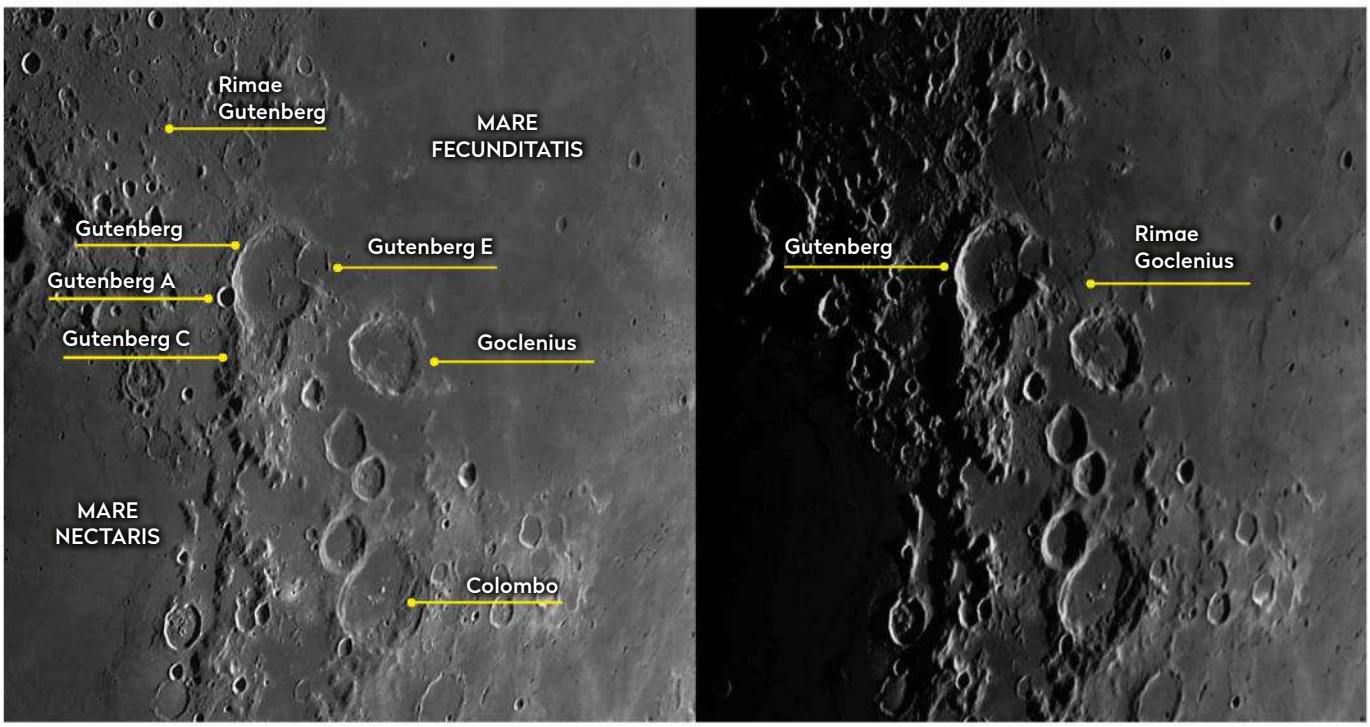
Gutenberg looks pretty battered although, with scrutiny, about three-quarters of its rim can be traced. The rim is interrupted in three places. The southwest rim section has had a subtle inversion due to 15km **Gutenberg A**, a fine example of a banded crater with smoothly descending inner walls leading to a 4km-diameter smooth circular floor. A banded crater is one which shows alternating light and dark radial bands on its inner walls.

To the south is 45km **Gutenberg C**, a feature that appears even older than Gutenberg. Gutenberg C appears to have formed on an elevated highland section, the northern portion of which has been removed by the formation of the main Gutenberg crater. The eastern rim of Gutenberg is the most damaged; 28km **Gutenberg E** has completely flattened it and is itself completely flooded but also incomplete, missing a small section of its southeast and southwest rim. Its lava surface is co-joined with Gutenberg's, appearing as a continuous stretch. A small 3.4km craterlet is located in the southern portion of Gutenberg E's floor.

Internally, Gutenberg's rim descends towards the smooth, lava-filled floor. The height of the rim is around 2km, the inner descent ramp varying in width from 4.1km in the southeast to 14.9km in the southwest. The best-preserved section to the west, ignoring the Gutenberg A intrusion, is around 9km wide. The crater's floor appears rough towards the east where peaks of mostly submerged structures can be seen. Linear rilles cross the floor, entering Gutenberg's northern rim as a pair of grabens – sunken floor sections between two fault lines – crossing just north of the 'central mountains' then passing across the elevated floor peaks.

The rilles are part of **Rimae Gutenberg**, a 330km set of linear rilles starting further to the northwest. Approximately 2.5km wide, these features are best seen with oblique illumination when the terminator is nearby. Another set of parallel rilles appears to run across the surface of Mare Fecunditatis, further to the east. These belong to **Rimae Goclenius**, the 55km-diameter crater Goclenius being located 114km, centre-to-centre, southeast of Gutenberg. One of the Goclenius rilles can also be seen passing through its parent crater. These impressive rilles are best seen with a 200mm or larger telescope.

▼ The lumps, bumps, rilles and ancient craters of this region are particularly rich to examine when the Sun is low



PETE LAWRENCE X 3

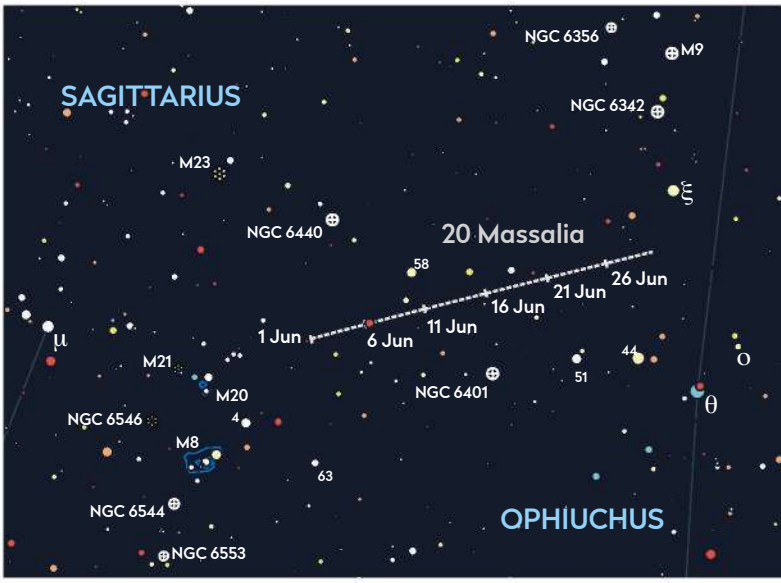
COMETS AND ASTEROIDS

Track the heftiest member of an inner-belt family of asteroids as it reaches opposition

Minor planet 20 Massalia reaches opposition on 16 June, when it will be in the southeast corner of Ophiuchus, northwest of the distinctive Teapot asterism in Sagittarius. At the start of June, it's positioned 2.5° west of the beautiful Trifid Nebula, M20. The Trifid shines with an integrated magnitude of +6.3, although at 28 arcminutes across its surface brightness is significantly lower. The Trifid lies 1.5° north and slightly west of the much brighter Lagoon Nebula, M8. If you fancy recording the passage of 20 Massalia this month, including this pair of iconic nebulae will make for an impressive record of its journey. Incidentally, if you're reading this in time, at 01:00 BST (00:00 UT) on 20 May, shining at mag. +10.7, Massalia is located 0.4° north of M20.

Massalia tracks west throughout the month, crossing the border into Ophiuchus on 10 June. It starts at mag. +10.5, brightening slightly to +10.0 at opposition when it will be located 0.7° east-southeast of mag. +6.5 52 Ophiuchi. At 01:00 BST (00:00 UT) on 30 June, 20 Massalia will be 1.3° southeast of mag. +4.4 Xi (ξ) Ophiuchi.

Massalia's orbit keeps it within the inner part of the main asteroid belt. It's the parent of a large collection of asteroids known as the Massalia family, a group with 6,000+ members. Massalia is a large S-type or stony asteroid with a mean diameter of 145km. Its orbital period is three years, nine months and its mean distance from the Sun is 2.41 AU (361,000,000km). Its orbit takes it out as far as 2.75 AU and in as close as 2.07 AU. It is believed to be nearly spherical in shape, having triaxial ellipsoidal dimensions of 160 x 145 x 132km. It is suspected to have large, flat surface regions and rotates once every 8.1 hours.



▲ **20 Massalia's path, passing near the Lagoon and Trifid Nebulae**

STAR OF THE MONTH

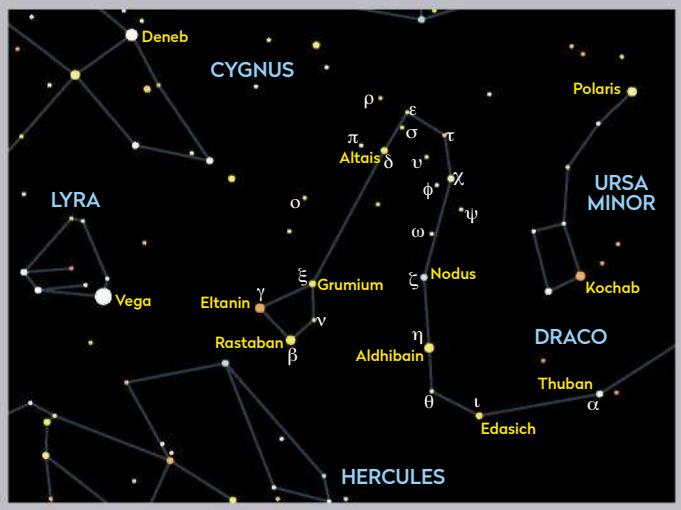
Edasich, an orange giant on the dragon's tail

Edasich (Iota (ι) Draconis) is a mag. +3.3 star in the curving tail of Draco, the Dragon. Located 31.8° from Polaris (Alpha (α) Ursae Minoris), Edasich is circumpolar from the UK and never sets. The name is a corruption of the Arabic term for 'the male hyena'. The Chinese name for Edasich is Zǐ Wēi Zuǒ Yuán yī, which means 'First Star of Left Wall of Purple Forbidden Enclosure', the enclosure asterism being formed by Iota, Theta (θ), Eta (η), Zeta (ζ), Upsilon (υ), 73, Gamma (γ) and Beta (β) Draconis.

Edasich is 1.8 times more massive, 12 times larger and 55 times more luminous than our own Sun. It has a spectral classification of K2 III, indicating that it's an orange giant star. It's estimated to be about 1.2 billion years old and, like our own Sun, rotates slowly with a speed of 1.5km/s.

Edasich gave rise to the first exoplanet discovered to orbit a giant star. The discovery, made in 2002, was interesting because the habitable zone for a giant is large, giving a reasonable chance that a planet would sit within it. Edasich's habitable zone extends 6.8–13.5 AU and the exoplanet (Edasich-b, named Hypatia) orbits with a semi-major axis of 1.45 AU, placing it too close to the parent star.

▼ **Edasich is an orange K-type giant star embedded in the tail of Draco, the Dragon**

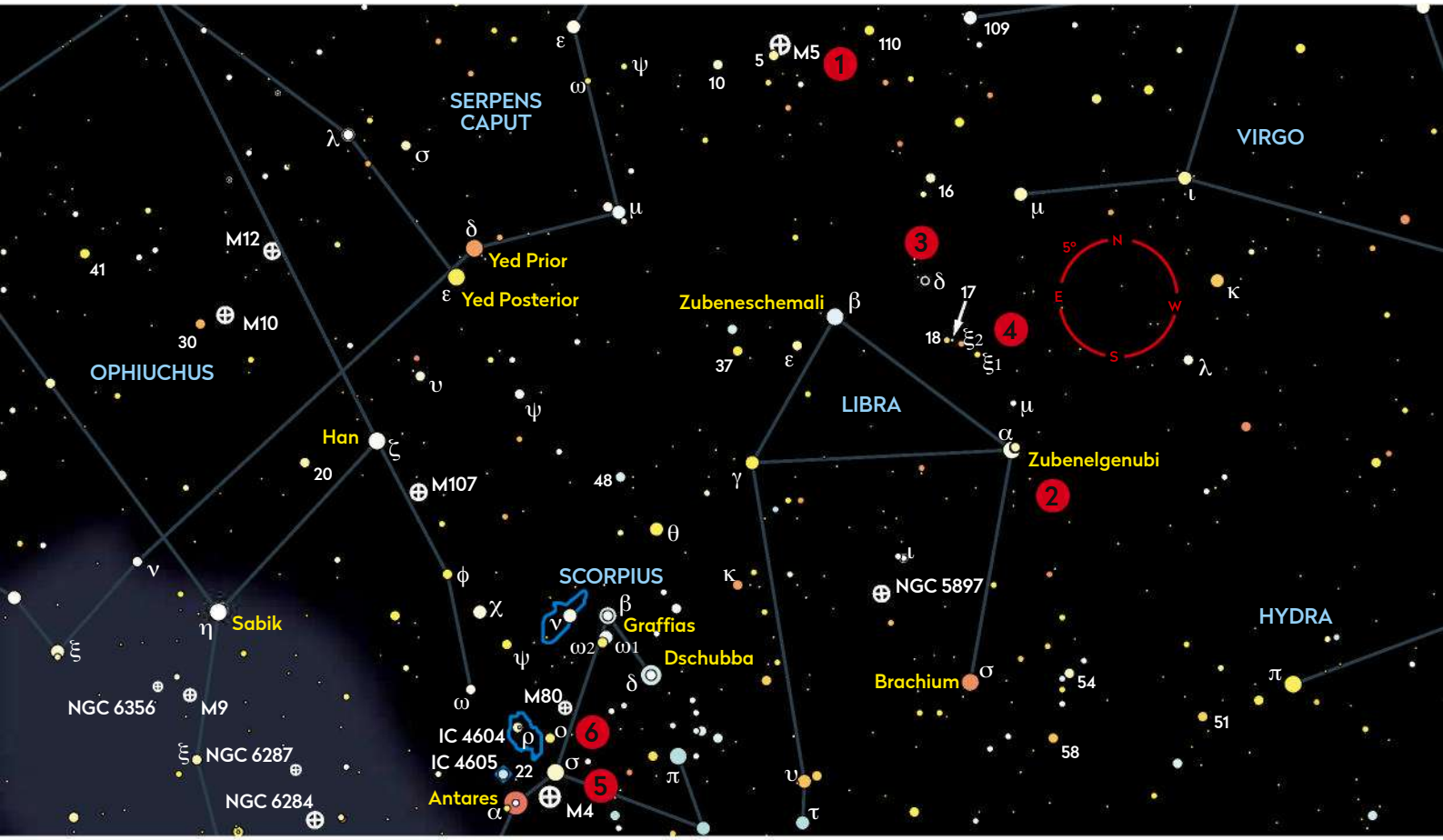


Edasich-c, discovered in 2021, lies outside the habitable range, with an orbital semi-major axis distance of 19.4 AU. Infrared excess from the system suggests the presence of a circumstellar debris disc in orbit around the star.

BINOCULAR TOUR

With Steve Tonkin

Skirt the edge of Libra, the Scales, and take a peek inside the Scorpion's claws



1. M5

10x50 Let's start with a fine globular cluster, M5, immediately north-northeast of mag. +5.0 5 Serpentis. It contains mostly Population II stars, which are among the oldest stars that we can see. They are thought to be more than 12 billion years old, which suggests that they formed very soon after our Galaxy did. In 10x50 binoculars, you should notice that M5 brightens towards the centre, exactly like a comet does. ☐ **SEEN IT**

2. Zubenelgenubi

10x50 In antiquity, the stars of Libra, the only non-living zodiac constellation, represented the claws of Scorpius, and the common name of mag. +2.7 Alpha (α) Librae, Zubenelgenubi, means 'southern claw' (the northern claw is mag. +2.6 Zubenelschamali (Beta (β) Librae). Zubenelgenubi is a nice easy binocular double star. Binoculars easily reveal the mag. +5.2 companion 3.5 arcminutes away. ☐ **SEEN IT**

3. Delta Librae

10x50 You'll find the variable (mag. +5.8 to mag. +4.4) Delta (δ) Librae 8° north of Zubenelgenubi. It's an eclipsing binary star (a pair of stars orbiting their common centre of mass) in which the drop in brightness, which lasts for about six hours, occurs as the dimmer star occults the brighter one. The orbital period is 2.3 days, so even during short summer nights you'll have several opportunities to notice the magnitude change. ☐ **SEEN IT**

4. Xi¹/Xi² and 17/18 Librae

10x50 Midway between Delta Librae and Zubenelgenubi lie two optical double stars (not gravitationally bound binaries). Mag. +5.8 Xi¹ (ξ¹) and mag. +5.4 Xi² (ξ²) Librae are separated by 0.75°. Half a degree northeast of Xi² is the other pair, mag. +6.6 17 Librae and mag. +5.8 18 Librae, which are nearly 10 arcminutes apart. There is about 50 lightyears between 17 and 18, and more than four times that between Xi¹ and Xi². ☐ **SEEN IT**

5. M4

15x70 M4 is nearly 1.5° west of bright orange mag. +1.0 Antares (Alpha (α) Scorpii). It is only 7,000 lightyears away, making it appear rather loose, and is one of the few globular clusters in which you may be able to discern some structure with 15x70 binoculars. M4 lies on the edge of the Milky Way, within a beautifully rich, colourful star-field that is more pleasing in binoculars than in a scope. ☐ **SEEN IT**

6. Rho Ophiuchi

10x50 If you navigate 3° north from M4, you'll find mag. +5.0 Rho (ρ) Ophiuchi. It is the bright component of a triple star, whose seventh-magnitude companions are 2.5 arcminutes to the north and west, respectively. If you have an exceptional southern horizon sky and fancy a challenge, see if averted vision enables you to detect a slight brightening surrounding the star. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

PETE LAWRENCE X 2

THE SKY GUIDE CHALLENGE

CAUTION
Never observe or image the Sun with the naked eye or any unfiltered optical instrument

Follow a daytime Venus as it reaches its 50%-lit phase and then shrinks

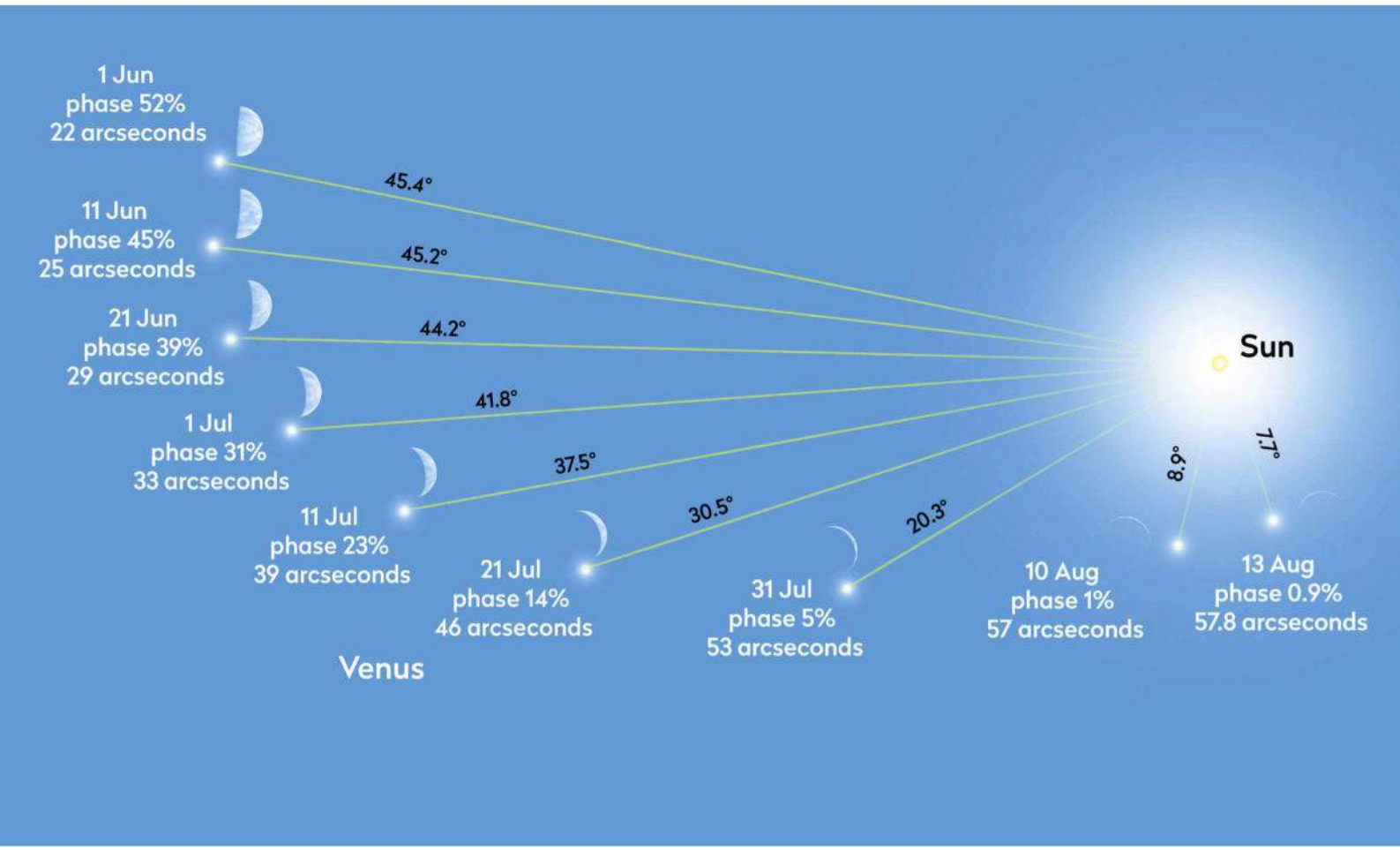
Venus reaches dichotomy, when it will be 50%-illuminated, on 4 June – in theory at least. In practice, when Venus is in the evening sky this occurs a few days earlier than prediction, due to atmospheric 'adjustment', a phenomenon known as the Schröter effect. The evening 50% phase represents the transition from a gibbous Venus into a crescent Venus, and where this planet is concerned, its crescent is very beautiful indeed. This month's challenge is to follow the development of the phase as the crescent gets thinner.

You might think that Venus isn't hard to find and the crescent is easy to see through a telescope. While both statements are true, the position of Venus in the evening sky deteriorates through June, its altitude and stability degrading as a result. The best way to view it is to find it during the day. There can either use your telescope's Go-To computer or old-school setting circles, but the net result is a higher planet with a more stable view of the crescent.

Caution needs to be taken because the Sun will be above the horizon and relatively close. Never attempt to find Venus near the Sun unless you really know what you are doing and take maximum precautions. Failure to heed this warning could lead to equipment damage or, even worse, damage to your eyes.

If you're an imager, a daytime view of Venus can be stabilised further by using an infrared-sensitive camera with an IR-pass filter fitted. This will dim the surrounding blue sky and give a view of the planet less affected by seeing. A high-frame-rate camera is idea for this. Capturing a few thousand short exposures will allow you to process the results in registration-stacking software such as RegiStax or AutoStakkert! to produce sharp renditions of the planet that can then be tweaked using your favourite graphics editor. For multiple captures, it's essential to record the date and time against each image to avoid confusion when you come back to them later. A common way to display the results is to combine them in a composite image showing the daytime sequence.

If you are able to take many daytime images of the planet you'll see the phase decrease, and the planet's apparent size increase to reveal the full beauty of that spectacular crescent. Recording the crescent's development becomes addictive, but remember that every day closer to inferior conjunction on 13 August brings a need for increased caution as the planet–Sun distance is decreasing too. It is possible to follow Venus through inferior conjunction in August, but it will be just 7.7° from the Sun when this occurs.



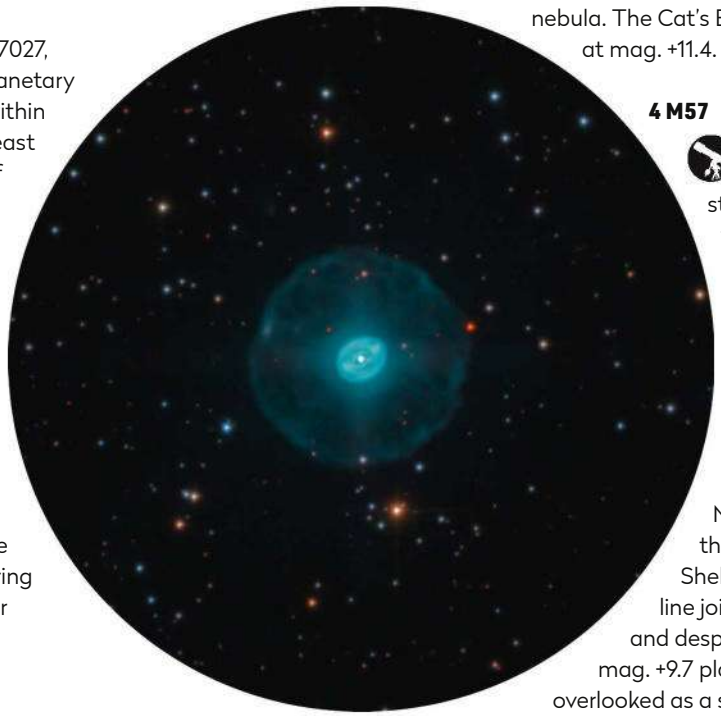
▲ **After greatest eastern elongation on 4 June, follow Venus's journey to become a thin crescent – but take care as it nears the Sun**

DEEP-SKY TOUR

We hunt six stunning planetary nebulae, the beautiful swan song of dying stars

1 NGC 7027

Let's start with NGC 7027, a 10th-magnitude planetary nebula in Cygnus. It's located within the busy Milky Way, 5.5° southeast of Deneb, 2.1° east-northeast of mag. +3.9 Nu (ν) Cygni. Known as the Jewel Bug Nebula, it's around 3,000 lightyears away and being a youthful and rare proto-planetary nebula, is small at 0.2 x 0.1 lightyears across. It appears 14 arcseconds across. Small telescopes reveal an object like a star at low and medium powers. A high magnification hints at an extended oval shape through smaller scopes, appearing more rectangular through larger instruments. ☐ **SEEN IT**



▲ **The Blinking Nebula, NGC 6826 appears to, well, blink when you switch between viewing it directly and using averted vision**

2 NGC 6826

We move towards the tip of Cygnus's northwestern wing for our next target, the Blinking Nebula, NGC 6826. The name reflects a common property of some planetary nebulae. Using direct vision through smaller apertures, a bright central star causes the fainter nebula to disappear from view. However, using averted vision the nebula blinks into view again. Look for NGC 6826 along the line from Deneb (Alpha (α) Cygni) towards Iota (ι) Cygni. It lies 2.6° from Iota. The nebula has an integrated magnitude of +8.8 and a total apparent size of 27 x 24 arcseconds. The central star shines at mag. +10.4. ☐ **SEEN IT**

3 NGC 6543

Located 21° northwest of the Blinking Nebula is another famous planetary nebula known as the Cat's Eye Nebula, NGC 6543. This one is found within a loop of the snake-like body of Draco, the Dragon, 7.2° west of mag. +3.1 Altais (Delta (δ) Draconis). Shining at mag. +9.8, with an apparent diameter of 20 arcseconds, it's visible through smaller scopes as an elongated smudge. If you have steady seeing and a scope over 200mm, try using a high magnification in conjunction with averted vision to see whether you can detect any of the faint, intricate detail in the inner regions of the nebula. The Cat's Eye Nebula's central star shines at mag. +11.4. ☐ **SEEN IT**

4 M57

Our next target is easy to find using the bright star Vega (Alpha (α) Lyrae), which forms the top edge of the large Summer Triangle asterism with Deneb. South of Lyra is a squashed-diamond pattern with Sheliak and Sulafat (Beta (β) and Gamma (γ) Lyrae respectively) at the southern edge. The famous Ring Nebula, M57, sits three-fifths of the way from Sulafat towards Sheliak, fractionally south of the line joining both stars. At low power and despite its 1.3-arcminute size, this mag. +9.7 planetary nebula can easily be overlooked as a star, but larger magnification reveals its extended oval shape. A 150mm or larger scope will show a darker patch inside the oval, the feature that produces its ring-like appearance. M57's central star is faint, shining at mag. +14.7. ☐ **SEEN IT**

5 NGC 6210

For mag. +9.3 NGC 6210, we head west from Lyra to find the dim but distinctive Keystone asterism in Hercules. Identify the eastern side, marked by mag. +3.2 Pi (π) and +3.9 Epsilon (ε) Herculis. Extend the line from Pi through Epsilon 1.2 times that distance to arrive at NGC 6210. Although it's small with an apparent diameter of 16 arcseconds, its surface brightness is relatively high – an ideal target for smaller scopes which reveal it to look like a small blue-green disc. Don't be afraid to pile on the power. An OIII or UHC filter may reveal extra outer detail through larger scopes. The central star for this nebula shines at mag. +12.7. ☐ **SEEN IT**

6 M27

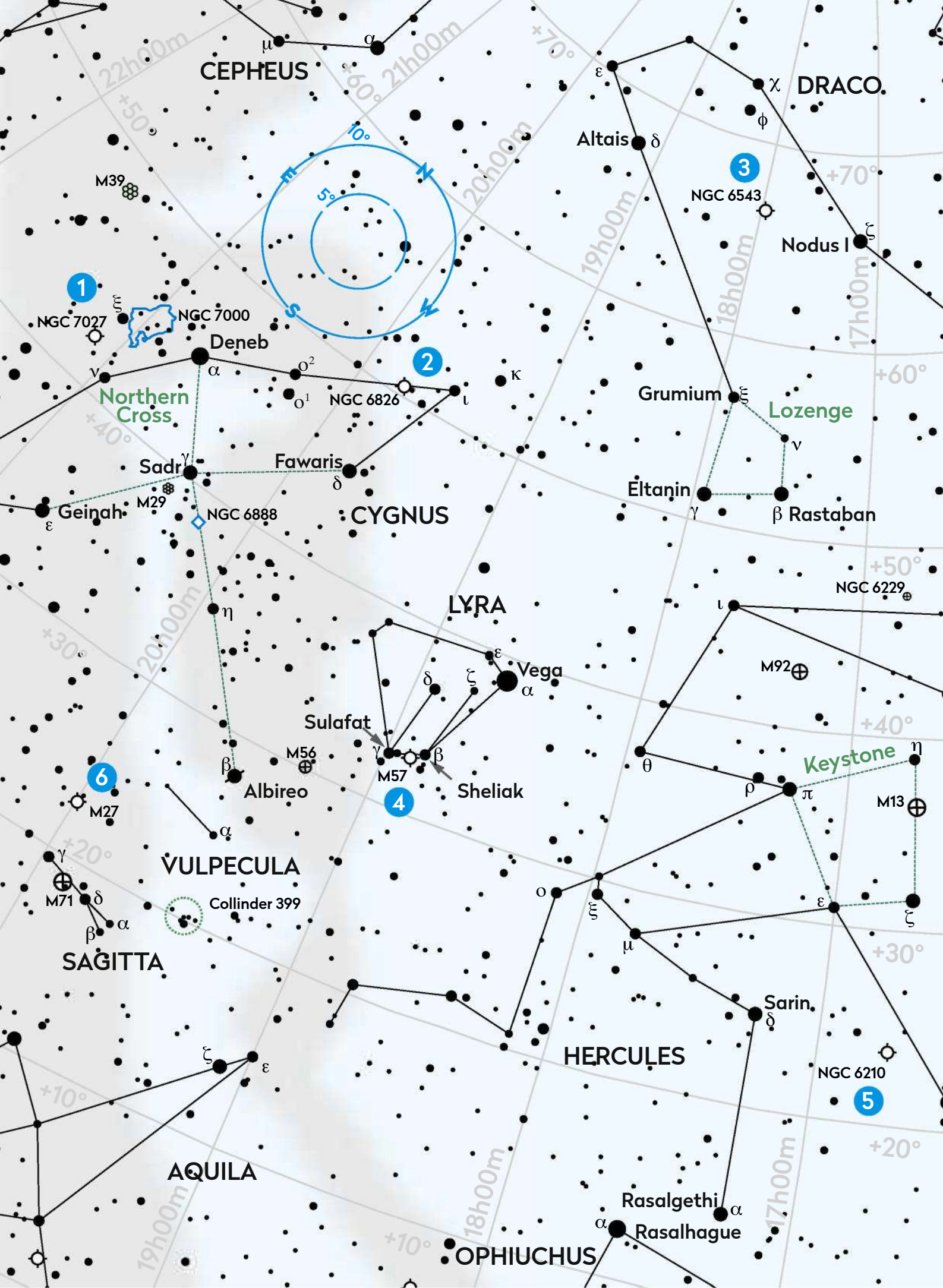
Finally, the spectacular Dumbbell Nebula, M27, in Vulpecula. It's easy to locate. Head back to Lyra and then to Cygnus. Extend the line from Sulafat through Albireo (Beta (β) Cygni) for the same distance again and you'll arrive at the nebula. It shines with an integrated magnitude of +7.4 and has impressive overall apparent dimensions of 8 x 5.6 arcminutes. A small scope will reveal its apple-core, pinched-waist appearance. An OIII filter works really well, revealing uneven textures. The two lobes are of unequal brightness, the southern one appearing smaller and brighter. A 300mm or larger scope should reveal the mag. +13.8 central star. ☐ **SEEN IT**

BERNHARD HUBL/CCDGUIDE.COM, CHART BY PETE LAWRENCE

This Deep-Sky Tour has been automated ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

More **ONLINE**

Print out this chart and take an automated Go-To tour. See page 5 for instructions


CEPHEUS
DRACO
Altais
NGC 6543
Nodus I
M39
10°
N
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W
5°
1
NGC 7027
NGC 7000
Deneb
Northern Cross
2
NGC 6826
Grumium
Lozenge
Eltanin
Rastaban
Sadr
Fawaris
Geinah
M29
NGC 6888
CYGNUS
LYRA
Vega
Sulafat
Sheliak
M57
M56
Albireo
6
M27
4
VULPECULA
Collinder 399
M71
SAGITTA
NGC 6229
M92
Keystone
M13
HERCULES
Sarin
NGC 6210
5
AQUILA
Rasalgethi
Rasalhague
OPHIUCHUS
3
+70°
+60°
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+40°
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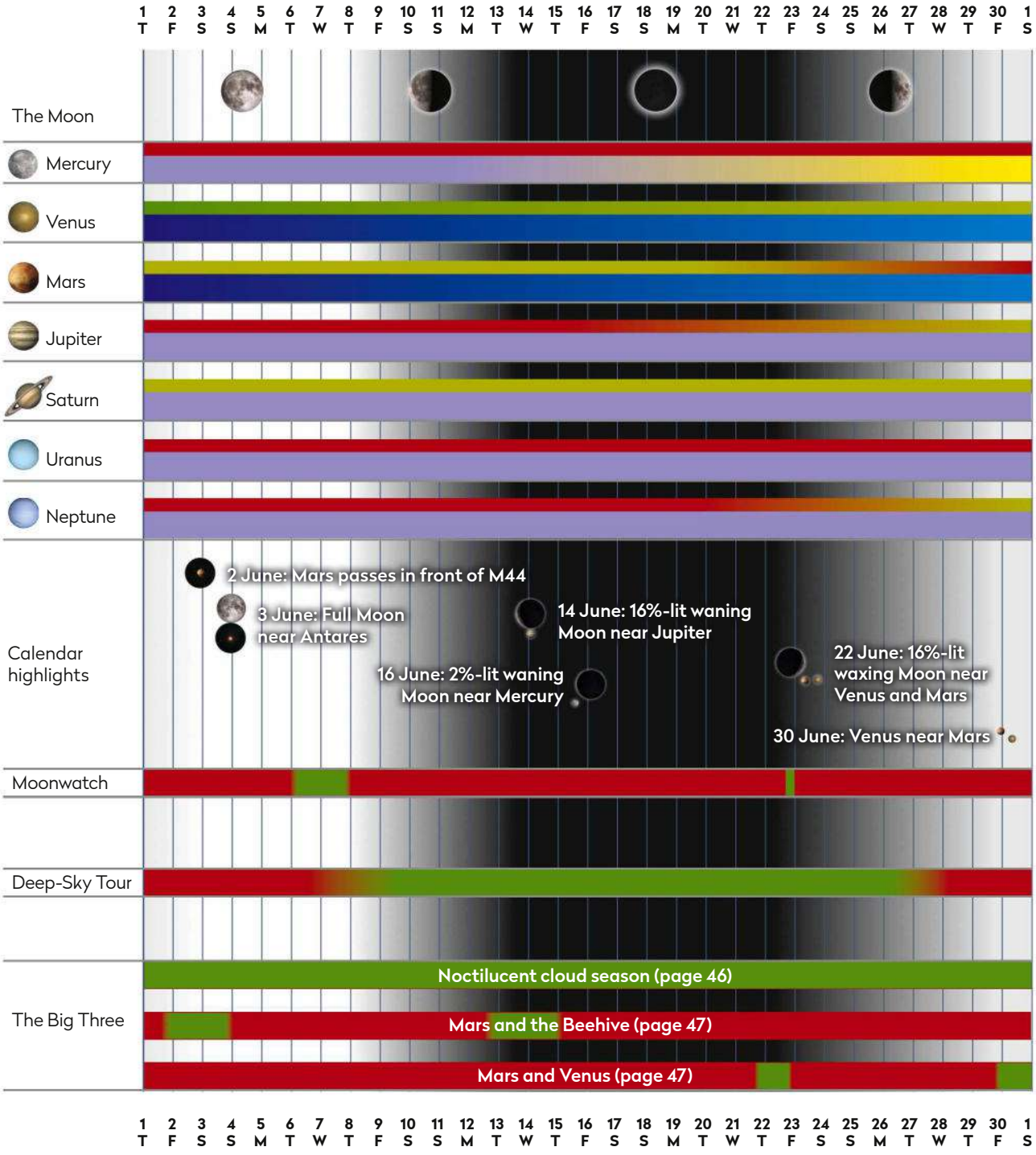
AT A GLANCE

How the Sky Guide events will appear in June


1 T 2 F 3 S 4 S 5 M 6 T 7 W 8 T 9 F 10 S 11 S 12 M 13 T 14 W 15 T 16 F 17 S 18 S 19 M 20 T 21 W 22 T 23 F 24 S 25 S 26 M 27 T 28 W 29 T 30 F 1 S
The Moon
Mercury
Venus
Mars
Jupiter
Saturn
Uranus
Neptune
Calendar highlights
2 June: Mars passes in front of M44
3 June: Full Moon near Antares
14 June: 16%-lit waning Moon near Jupiter
16 June: 2%-lit waning Moon near Mercury
22 June: 16%-lit waxing Moon near Venus and Mars
30 June: Venus near Mars
Moonwatch
Deep-Sky Tour
The Big Three
Noctilucent cloud season (page 46)
Mars and the Beehive (page 47)
Mars and Venus (page 47)
1 T 2 F 3 S 4 S 5 M 6 T 7 W 8 T 9 F 10 S 11 S 12 M 13 T 14 W 15 T 16 F 17 S 18 S 19 M 20 T 21 W 22 T 23 F 24 S 25 S 26 M 27 T 28 W 29 T 30 F 1 S

KEY

Observability

Optimal | Poor

Best viewed

Morning twilight | Daytime | Evening twilight | Night

Sky brightness during lunar phases

Dark (first quarter) | Light (full Moon) | Dark (last quarter) | Total darkness (new Moon)

IC Inferior conjunction (Mercury & Venus only)

SC Superior conjunction

OP Planet at opposition

Meteor radiant peak

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CHART BY PETE LAWRENCE

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Noctilucent clouds *on the rise*

Night-shining clouds have fascinated sky-watchers for almost 140 years. **Rob Banino** finds out what they tell us about our changing atmosphere

JUHKU/ISTOCK/GETTY IMAGES

First identified in 1885, the late-night, high, shimmering clouds are now a spectacle more of us will be lucky enough to see

The Krakatoa eruption of 1883 was one of the deadliest in recorded history. The volcano, which lies on an island in Indonesia's Sunda Strait, had been threatening to blow for months. It had been sending plumes of ash and steam into the sky since May of that year, but at 1pm on 26 August the pressure beneath its rocky cones finally became too much.

Four increasingly violent explosions over the next 24 hours all but destroyed the island. They killed over 36,000 people and could be heard 3,500 kilometres away in Australia. Twenty-one cubic kilometres of rock and ash was blasted across 800,000 square kilometres and over 80 kilometres up into the air.

So much ash was released into the atmosphere, the region was plunged into darkness for two and a half days. As the ash diffused and drifted around the world, its chemicals absorbed different wavelengths of light, causing spectacular red and orange sunsets and making the Moon glow blue for months.

There was enough ash lingering in the atmosphere a year later to cause summer temperatures in the Northern Hemisphere to drop by an average of 0.4°C.

Then, on a clear summer's night in 1885, amateur astronomers in the German town of Bad Kissingen spotted some new, mysterious-looking clouds. It wasn't so much that they were thinner and wispier than regular clouds, but they were visible after dark. They actually appeared to be shining. ▶

Putting on a show over Bruges, Belgium. Night-shining clouds are an elusive sight in the summer months – but that's changing

▶ Those mysterious clouds would become known as noctilucent, or night-shining, clouds (NLCs). They can be seen every year between May and August and have become a favourite target for many observers. And since that first sighting, we've gradually learned more about them.

We know NLCs can only be seen from latitudes of 45–80° both north and south, and they form around 75–85 kilometres above Earth's surface, at the top of the mesosphere, the highest part of our atmosphere. (The thermosphere and exosphere are both higher and officially part of Earth's atmosphere, but the air density is so low that they're generally considered to be 'space'. The ISS, for example, orbits in the thermosphere and most satellites orbit in the exosphere.)

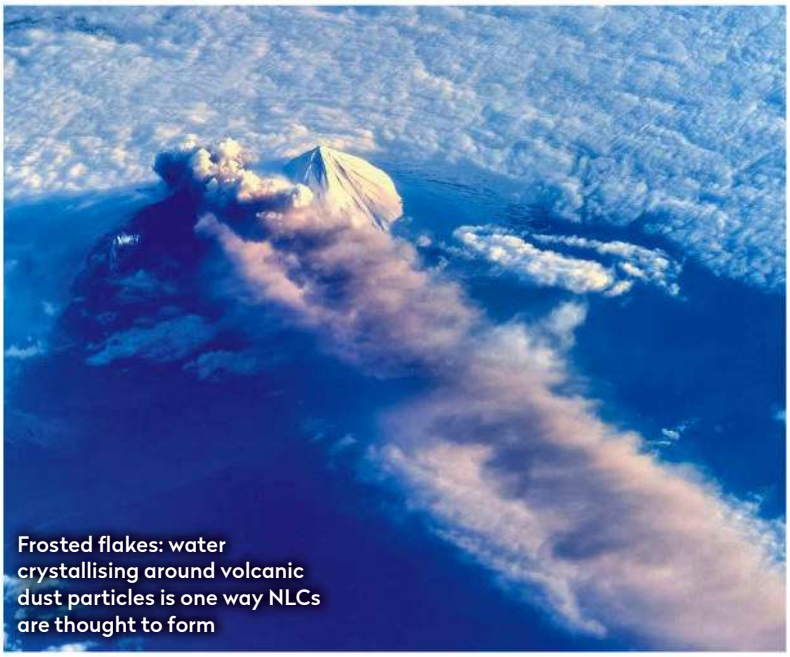
Ingredients for a cloud

For a long time, much about NLCs remained mysterious, even contradictory. For instance, their altitude: clouds need water vapour to form, yet the mesosphere is drier than the Sahara Desert. Then there's their occurrence only during warm summer months, when the mesosphere is at its coldest. And finally, they appear to shine brightly, often shimmering in silvery blue or sometimes orangey-red, but are only seen after dark. Nothing about NLCs seemed to make sense.

Yet based on when NLCs were first spotted, there was reason to believe they could be connected to the Krakatoa eruption.

"For NLCs to exist, you need three things," says Dr Gregory Brown, an astronomer at the Royal Observatory Greenwich. "The temperature must be very cold, about –120°C. You need a condensation centre – a particle, basically, something for water or ice to condense around and start the process of creating a cloud. In the case of NLCs, it's thought these condensation centres are probably meteoric dust, although volcanic dust could potentially do the same thing. So that's one possible connection to Krakatoa.

"You need water, because the mesosphere is incredibly dry – many times drier than the most arid desert on Earth. And one thing the Krakatoa eruption



Frosted flakes: water crystallising around volcanic dust particles is one way NLCs are thought to form

KURMYSHOV/ISTOCK/GETTY IMAGES, TORONTONIAN/ALAMY STOCK PHOTO, NASA EXPLORERS PROGRAM

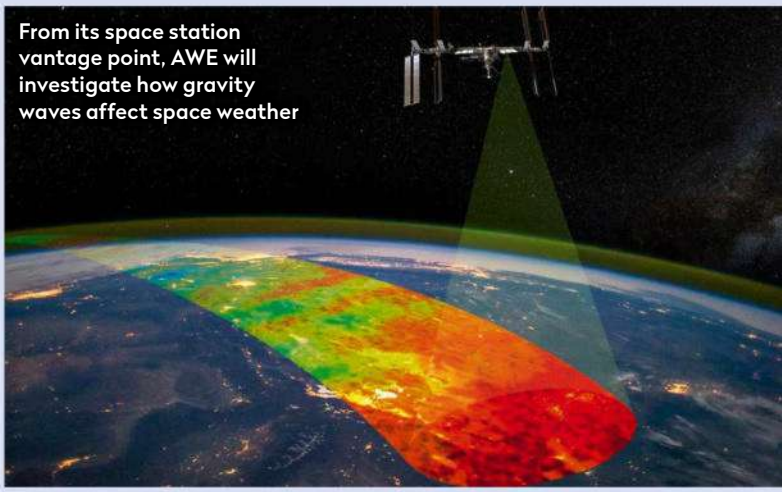
Cloud detectives: AIM and AWE

Could a new instrument on the ISS solve the mystery of increasing NLCs?

Various satellites have observed noctilucent clouds (NLCs) over the years, but the first one dedicated to studying them was NASA's Aeronomy of Ice in the Mesosphere (AIM). With Prof James Russell of Hampton University in Virginia as its principal investigator, and costing $140m, it launched on 25 April 2007 to begin its two-year mission.

Almost 16 years later, in March 2023, NASA finally ceased AIM's operations after power loss in its battery left the satellite unable to receive commands. The data AIM gathered was crucial for our understanding of the causes and formation of NLCs, and featured in 379 peer-reviewed scientific papers.

AIM's successor, the Atmospheric Waves Experiment (AWE), is scheduled to launch in December 2023. It will perch on the International Space Station and study gravity (or buoyancy) waves, which transport heat and energy produced by powerful weather disturbances in the troposphere up to the higher regions of Earth's atmosphere.



From its space station vantage point, AWE will investigate how gravity waves affect space weather

"The Krakatoa eruption released vast amounts of water vapour into the atmosphere. That might be what triggered the formation of the first NLCs" – Gregory Brown

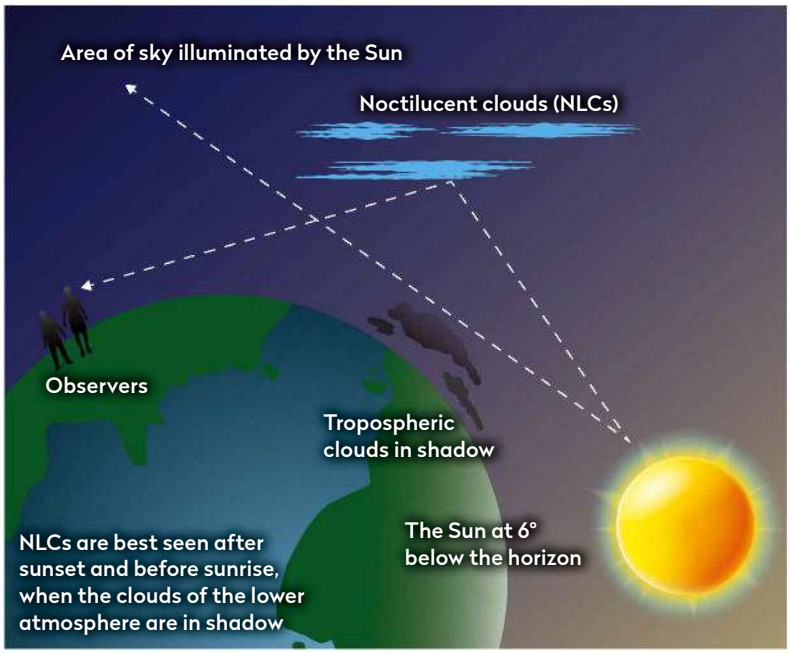
did was release vast amounts of water vapour into the atmosphere. That might have been the thing that triggered the formation of the first NLCs we observed – not necessarily the condensation centres created by the volcanic dust, but the steam the eruption pushed up into the mesosphere."

For a long time that was the working theory for what was causing NLCs: steam from volcanic eruptions condensing around meteoric dust particles in the freezing temperatures of the mesosphere. But the first NLC mystery we managed to solve was why they only appear after dark during the summer. And it's because they're so far above Earth's surface.

NLCS are too tenuous to be visible during the day, but because they're so high, ice crystals in NLCs can reflect sunlight once the Sun has dropped below the horizon. Essentially they're giant, high-altitude reflectors sitting in the path of a light source that's out of sight to those of us on the ground.

"You can normally see NLCs about an hour after sunset or an hour before sunrise during the middle of the summer, at astronomical twilight," says Aidan McGivern, a Met Office meteorologist. "The Sun is sitting just below the horizon, providing enough light from underneath to illuminate these very thin clouds of ice crystals."

And they are only visible from late May through to mid-August, in the Northern Hemisphere, because that's when temperatures in the mesosphere are at their coldest.


Area of sky illuminated by the Sun
Noctilucent clouds (NLCs)
Observers
Tropospheric clouds in shadow
The Sun at 6° below the horizon
NLCs are best seen after sunset and before sunrise, when the clouds of the lower atmosphere are in shadow

A spurt of sightings

Since that initial sighting in 1885, we've observed and studied NLCs whenever they appeared. We've become more familiar with them, through ground- and space-based observations, and begun to gain an understanding of them. But just as we were solving the mysteries of where, when and how they form, there was a sudden change: NLCs started appearing more frequently.

Data gathered over a 40-year period from the mid-1960s to the mid-2000s shows evidence for ▶

Curiosity captured the unusual clouds over Mont Mercou on 19 March 2021

NLCs on Mars

Our robotic eyes on the Red Planet have shown that Earth isn't the only world that experiences night-shining clouds

Thanks to NASA's Curiosity rover, we can now say we've spotted noctilucent clouds on another planet. While exploring the Martian surface in the first few months of 2021, the rover began imaging wispy clouds that scattered light from the setting Sun and shimmered with colour.

Analysis of the images determined that these clouds were unlike typical Martian clouds, which are composed of water ice and float no higher than 60km up in the atmosphere.

These new clouds were sitting at higher altitudes, as their shiny appearance against a dark sky indicated that they were catching light from the setting Sun. Such a height would put the clouds in a very cold part of Mars's atmosphere where it would be cold enough to freeze carbon dioxide into crystals of dry ice that would reflect sunlight.

▶ sightings of NLCs becoming more common. And not just because more people are looking for them. Computer simulations modelling the atmosphere over the Northern Hemisphere from 1871 until 2008 found NLCs became significantly more visible during that period.

"In the 19th century, NLCs were probably visible only once every several decades," says Prof Franz-Josef Lübken at the Leibniz Institute of Atmospheric Physics, who led the 2018 computer modelling study. "[But] people living in the mid-to-high latitudes now have a good chance of seeing NLCs several times each summer."

There's been no significant increase in volcanic eruptions or, as far as we're aware, meteoric activity during that period, so what could explain the increase? One theory was that changes in solar activity might be to blame, but the increasing NLC trend doesn't correlate with the 11-year solar cycle, so that's effectively been ruled out. That leaves us with only one other possible explanation: a change in Earth's atmosphere. The sort of change that can be linked to human activity.

"An increase in carbon dioxide in the atmosphere leads to higher temperatures in the troposphere [the lowest level of Earth's atmosphere]," says McGivern. "But because greenhouse gases like carbon dioxide trap heat closer to the surface, the stratosphere and the mesosphere, further up, cool down. When you have lower temperatures in the mesosphere, you're more likely to get particles of water vapour condensing into ice crystals to form NLCs."

But carbon dioxide isn't the only problem. "What's probably a more likely cause for the increased sightings of NLCs is the increasing amount of methane in the atmosphere," says McGivern.

"A more likely cause for the increased sightings of NLCs is the increasing amount of methane in the atmosphere" – Aidan McGivern

Methane, another greenhouse gas that has a more potent effect than carbon dioxide, reacts with ultraviolet radiation in sunlight to form water vapour. And if you combine more water vapour with a colder mesosphere, chances are you get more NLCs.

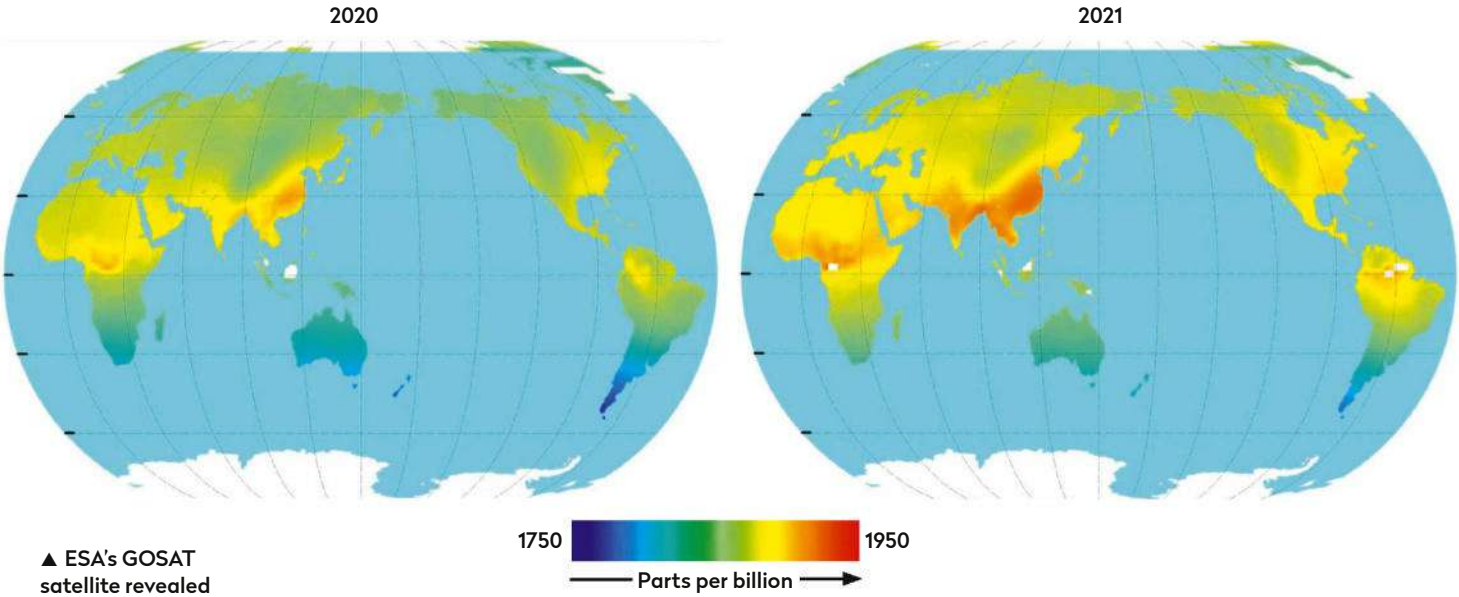
"Although it's not clear whether this connection does actually exist, there is some evidence to say NLCs might be one of the more obviously visible signs of climate change," says Brown. "[NLCs] are not damaging in and of themselves, but they show how the atmosphere has subtly, but very importantly, changed due to human emissions."

Plenty still to learn

There are still more NLC mysteries to solve. For instance, what role space traffic might play in their variability. A 2005 study showed that water vapour from Space Shuttle launches could increase NLCs at higher latitudes, while a study published in 2022 showed a correlation between rocket launches and the frequency of NLCs appearing at latitudes of 56–60°. Then there's how gravity (or buoyancy)

Catching a fine, structured NLC display tops the wishlist of many summer sky-watchers

NASA/JPL-CALTECH/MSSS, GOSAT, RENE LEHISTE/ITOCK/GETTY IMAGES



▲ ESA's GOSAT satellite revealed the year on year increase in methane concentrations across the world, a likely factor in more frequent NLC displays

waves, generated by weather systems moving through the troposphere, might affect NLCs, which NASA plans to launch a mission to study later this year (see Cloud Detectives, page 63).

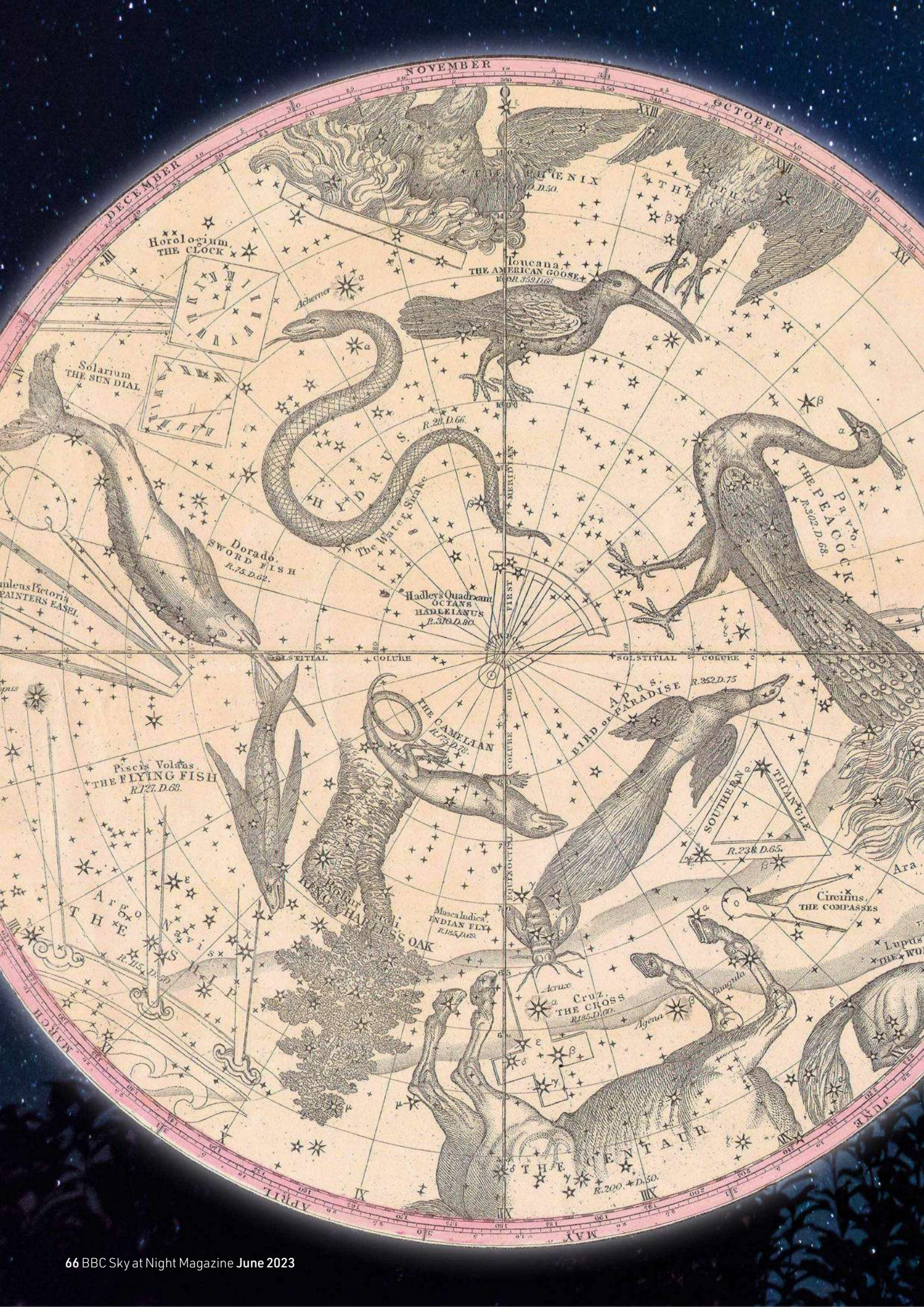
But perhaps the most puzzling question – for casual observers, at least – is why these clouds, which form within Earth's atmosphere, are seemingly of greater interest to astronomers and the space science community than to meteorologists? Fortunately this mystery has a simple solution: by floating near the edge of space, just shy of the Kármán Line, NLCs are effectively out of range for meteorologists.

"Although they are technically clouds and they form in the same way that clouds in the troposphere form, they don't particularly play a role in our day-to-day weather," says McGivern. "You wouldn't factor them into our weather models, and they're so thin and high up that they don't have much of a consequence for our climate."

While scientific opinion seems to agree that climate change is a likely cause of the increase in NLCs we are seeing, this hasn't yet been established conclusively. After all, scientists have only known about the phenomenon for a little over a century, and have only been able to study the clouds from space since the 1960s and 1970s. Existing data only covers a relatively short span of time – too short to draw any concrete conclusions – yet human activity in the form of the Industrial Revolution, the burning of fossil fuels and its effect on the atmosphere, all seem to tally with the changes we're seeing.

What's clear is that NLCs still have much to teach us. And as much as they may have changed since we first spotted them in 1885, NLCs' contradictory nature has remained constant. They're still most visible after dark and before dawn; they still require the coldest of temperatures that occur during the hottest months of summer; and they still rely on the presence of water in one of the driest parts of Earth's atmosphere. And, as Brown points out, "They're the one type of cloud that astronomers like to see".

Rob Banino is the managing editor of *BBC Science Focus Magazine*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THE AMERICAN GOOSE
Achernar
Solarium
THE SUN DIAL
HYDRUS
The Water Snake
Dorado
SWORD FISH
Hadley's Quadrant
OCTANS
HADLEIANUS
Pavo
THE PEACOCK
Apus
BIRD OF PARADISE
THE CAMELIAN
Piscis Volans
THE FLYING FISH
SOUTHERN TRIANGLE
Circinus
THE COMPASSES
Musca Indica
INDIAN FLY
Crux
THE CROSS
Agena
Fauguia
Lupus
THE CENTAUR
SOLSTITIAL COLURE
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FIRST MERIDIAN

From a bird of paradise to a flying fish, we still use the southern sky patterns first mapped out more than 400 years ago

Who invented the *southern constellations?*

Ian Ridpath uncovers how it took 150 years of exploration to fill the skies of the Southern Hemisphere with 26 new constellations

On seeing a chart of the Southern Hemisphere constellations, the Lick Observatory astronomer Heber Doust Curtis is reputed to have declared: "It looks like somebody's attic!".

While it's true that the southern constellations include such technological relics as an air pump, a chemical furnace and a pendulum clock, there are also exotic animals such as a peacock, a bird of paradise and a dorado chasing a flying fish – not to mention the oak tree that was planted by Edmond Halley to commemorate King Charles II, only to be later felled by a Frenchman.

Before the first European seafarers ventured around the tip of Africa to open trade routes to India and the Far East, the sky around the south celestial pole was a blank slate for Western astronomers. The 48 Greek constellations in Ptolemy's book the *Almagest* of 150 AD went only as far south as Centaurus and Argo Navis. Beyond that lay the celestial equivalent of terra incognita, beneath the horizon for European observers. ▶

Ian Ridpath is a veteran astronomy writer and editor of *The Antiquarian Astronomer*. Find out more about the history of the constellations on his website at **bit.ly/startales**

ARTOKOLORO/ALAMY STOCK PHOTO, HOLGER LINK/ISTOCK/GETTY IMAGES

The ship Mauritius, part of the Eerste Schipvaart, the first Dutch trading expedition to set sail to the East Indies in 1595

Exploring the southern sky

▶ One man was determined to fill in this blank area of sky: the Dutch cartographer and theologian Petrus Plancius (1552–1622). When the first Dutch trading expedition to the East Indies, the Eerste Schipvaart, set sail in April 1595, Plancius instructed several members of the ships' crews to make positional observations of the southern stars. Foremost among these trusted observers was Pieter Dirkszoon Keyser (c1540–96), chief navigator on the Hollandia, joint-largest of the four ships in the fleet.

The Dutch fleet arrived at Madagascar, latitude 23° south, in September 1595 where they remained for several months to resupply and recover from scurvy and malnutrition. It was during this stopover that Keyser made most of his observations, measuring star positions from the crow's nest of his ship, probably using an astrolabe given to him by Plancius.

Resuming their voyage, the expedition eventually reached the island of Sumatra in June 1596 before moving on to their final destination of Bantam (now Banten) in Java, where Keyser died. According to a contemporary account, he died while observing from the crow's nest, although the cause is not stated.

Fortunately, his legacy did not die with him. When the depleted fleet returned to the Netherlands in August 1597 with its precious cargo of spices from the East, they carried with them another, more lasting treasure: Keyser's observations of the southern stars. These were duly delivered to Plancius.

The Southern Dozen

Keyser's stars, divided into 12 new constellations (see table, right), first appeared on a celestial globe made by Plancius in 1598, and again two years later on a globe by his colleague Jodocus Hondius (1563–1612). These constellations were the first significant additions to the sky since Ptolemy's time. There were 122 stars in the 12 constellations, plus five more stars that formed a southern extension of Eridanus, and 12 'unformed' stars that were not part of any constellation. Whether Keyser observed more stars than this we do not know, because his original records are long lost.

Who actually invented these 12 new southern figures? It was probably not Keyser, since he would not have had a chance to do so before his untimely death. Some historians believe they were invented by Plancius after receiving Keyser's observations. But there is another candidate: Frederick de Houtman (1571–1627), younger brother of the commander of the Dutch fleet, Cornelis de Houtman (1565–99). Frederick was also a crew member of the Eerste Schipvaart and made celestial

▲ Map-maker Petrus Plancius (1552–1622) enlisted Dutch traders to make records of the southern stars

The Southern Dozen

The constellations introduced by Keyser, de Houtman and Plancius in 1596–1603

Constellation name	Representing
APUS	Bird of paradise
CHAMAELEON	Chameleon
DORADO	Goldfish (dolphinfish)
GRUS	Crane
HYDRUS	Little water snake
INDUS	Native Indian
MUSCA	Fly
PAVO	Peacock
PHOENIX	Phoenix
TRIANGULUM AUSTRALE	Southern Triangle
TUCANA	Toucan
VOLANS	Flying fish

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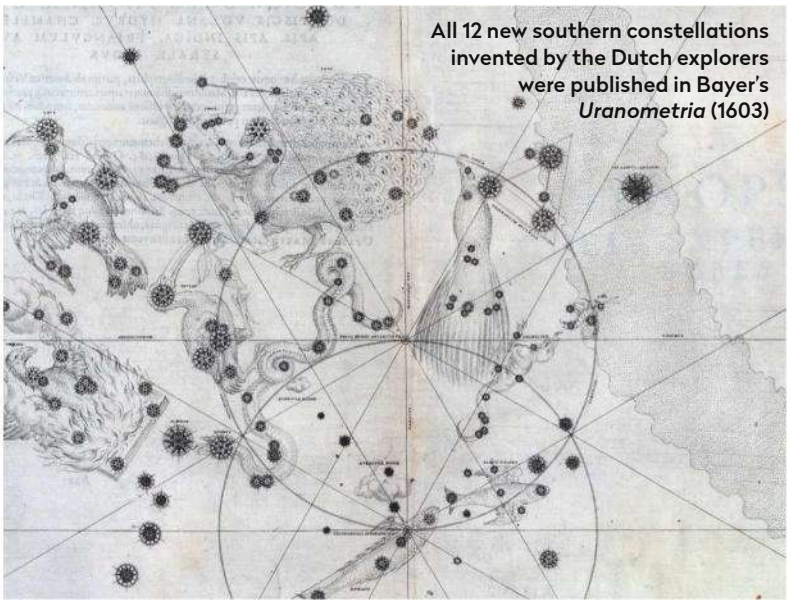
▲ **In 1603, the Dutch explorer Frederick de Houtman published a catalogue of over 300 stars he had observed during two voyages to the East Indies, building on the work of his compatriot Pieter Dirkszoon Keyser**



All 12 new southern constellations invented by the Dutch explorers were published in Bayer's *Uranometria* (1603)

observations of his own, independently of Keyser.

After Keyser died, Frederick would have had access to his records. We can imagine him whiling away the time on the long voyage home by collating the joint observations and grouping them into constellations representing the wondrous things they had seen. It seems fair to assign credit for the invention of these new Southern Dozen constellations jointly to Keyser and de Houtman, and their mentor Plancius.

Bayer's southern star chart

The new southern constellations made their first appearance in print, as distinct from on a globe, in the great star atlas *Uranometria* in 1603 by the German astronomer Johann Bayer. Bayer devoted one plate to each of the 48 Ptolemaic constellations, but in addition he gave the new Southern Dozen a separate 49th chart of their own, creating the first all-sky star atlas. For European astronomers at the start of the 17th century, Bayer's chart of this hitherto invisible area of sky must have been as much of a revelation as the first photographs of the far side of the Moon were in more recent times.

Since globes were expensive, few people ever saw them. By contrast, Bayer's atlas was widely circulated. His Chart 49 was the first time that most astronomers found out about the new constellations, and as a result he was often wrongly credited as their inventor.

In addition, Bayer's southern chart showed the two Magellanic Clouds, labelled Nubecula Major and Nubecula Minor, as well as the first record of 30 Doradus (the Tarantula Nebula) and the globular cluster 47 Tucanae.

De Houtman's star catalogue

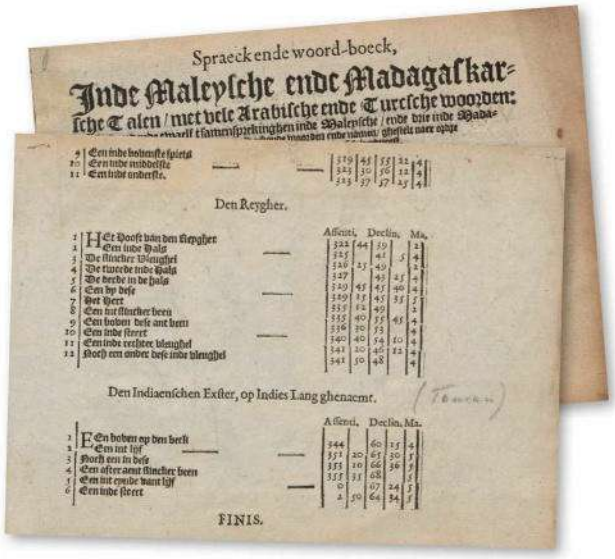
Seven months after their return from the Eerste Schipvaart, the de Houtman brothers set off again to the East Indies. In 1599 they reached Aceh in northern Sumatra. There Cornelis was killed in a dispute fomented by rival Portuguese traders and Frederick was imprisoned for two years by the Sultan of Aceh until a ransom was paid for his release.

During his time in captivity, de Houtman studied the local Malay language and added to the southern stars he and Keyser had observed on the first voyage. On his return to Holland in 1603, he published his observations as an appendix to a Malay and Madagascan dictionary that he had compiled, surely one of the most unlikely pieces of astronomical publishing in history.

De Houtman's catalogue lists 304 stars, of which 111 lay in the new Southern Dozen constellations. The remainder had either already been listed by Ptolemy or were additions to the Ptolemaic constellations, notably Argo Navis and Centaurus.

Halley heads south

There things stood for 75 years, until the 20-year-old Edmond Halley (1656–1742) set out for the island of St Helena in the South Atlantic. His intention was to produce a southern extension to the star catalogue being prepared at Greenwich by his mentor John ▶


Spraeck ende woord-boeck,
Inde Maleysche ende Madagaskar-
sche Talen / met vele Arabische ende Turcsche woorden:
Den Reygher.
Den Indiaensehen Exster, op Indies Lang ghenaemt.
FINIS.

▲ **De Houtman divided his 304 southern stars between the 12 newly invented figures and Ptolemy's existing ones, and published them at the end of a Malay and Madagascan dictionary he compiled on his journey**

▲ **The 12 new southern constellations were first shown on celestial globes such as this one made in 1603 by the Dutch cartographer Willem Janszoon Blaeu**

▶ Flamsteed (1646–1719), the first Astronomer Royal. He took with him a large sextant with telescopic sights, a smaller quadrant, a pendulum clock and a number of refracting telescopes, all paid for by his wealthy father. He set these up in a small stone building on a ridge now called Halley's Mount, near the centre of the island.

What he had not anticipated was the weather, which was far cloudier than he had hoped, allowing no more than an hour's observing per night. Even when it was clear, he complained that his instruments and notebook rapidly became soaked with dew.

Halley spent just over a year observing on St Helena, from early February 1677 to late February 1678. On his return to England he was quick to get his results into print, starting with a star chart that was printed by July 1678. His accompanying catalogue, *Catalogus Stellarum Australium*, was published in early 1679. It contained 341 stars, far fewer than he must have hoped for when he set out.

Halley adopted the Southern Dozen constellations invented by Keyser and de Houtman, and also added a new one of his own: Robur Carolinum – Charles's Oak, to commemorate the tree in which Charles II of England had hidden to escape the Parliamentary forces after his defeat at the Battle of Worcester in 1651. Halley formed it from stars that had previously been part of Argo Navis, the ship of the Argonauts. Among its stars was the peculiar variable we now know as Eta Carinae.

The overall accuracy of Halley's catalogue was restricted by errors in the positions of his reference stars, for which he relied on Tycho Brahe's observations. Flamsteed's assistant Abraham Sharp (1653–1742) later recalculated the coordinates of Halley's stars using Flamsteed's improved positions for the reference stars, and published the results in 1725 as a supplement to Flamsteed's posthumous *Catalogus Britannicus*, thereby turning that work into the first all-sky catalogue.

▲ **Edmond Halley's star chart, published on his return from St Helena in 1678. As well as depicting the 12 new southern constellations, he introduced a new one of his own, Robur Carolinum**

The French collection

Even with the Southern Dozen constellations now firmly established, there were still yawning gaps between them. These were filled by a French astronomer, Nicolas Louis de Lacaille (1713–62), who is largely responsible for arranging the southern sky into the way we see it today.

In 1750, Lacaille sailed from France to South Africa where he set up a small observatory at the Cape of Good Hope (not yet known as Cape Town) under the famous Table Mountain. From August 1751 to July 1752, he measured the positions of some 9,800 stars between the Tropic of Capricorn and the south celestial pole using a telescope of a mere 13.5mm (half an inch) aperture mounted on a 3-foot quadrant.

To accommodate these stars, he created 14 new constellations (see table, right). Whereas the Dutch explorers had mostly named their constellations after exotic animals, Lacaille commemorated instruments of science and the arts, the exception being Mensa which he named after the Table Mountain under which he had carried out his observations. As well as these new creations, he uprooted Halley's Robur Carolinum, evidently considering an homage to an English king an inappropriate addition to the southern sky.

On his return to France in 1754, Lacaille presented the French Royal Academy of Sciences with a chart

▼ **The French astronomer Nicolas Louis de Lacaille (1713–62) invented 14 new southern constellations after a year observing the sky in South Africa**

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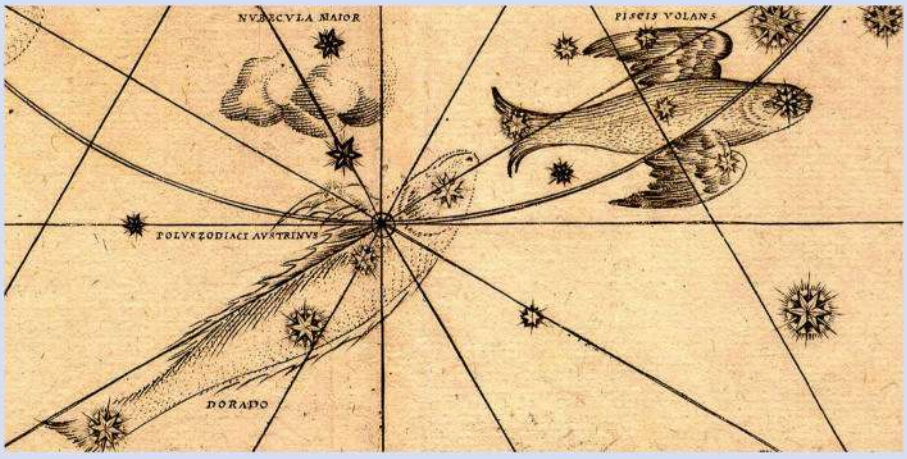
The curious tale of Doradus

Why is there a goldfish in the southern sky?



▼ Dorado, the goldfish, chases Volans, the flying fish, across the southern sky in Bayer's *Uranometria*

Near the Large Magellanic Cloud is a little tableau of Dorado the goldfish chasing Volans the flying fish. And you might wonder, why is there a goldfish in the sky? But it's not the sort of goldfish that you keep in a bowl.

It's actually a dolphinfish, also known by its Hawaiian name of mahi-mahi, which is much bigger and more aggressive. They are caught for sport and for eating. They really do appear gold, and they chase flying fish. Indeed, one reason flying fish learned to fly was to escape predators such as dorado. The early explorers must have seen dolphinfish chasing flying fish on their voyages, and they put their images in the sky.

of the southern heavens containing these new constellations. An engraved version was published two years later in their *Mémoires*, along with a preliminary catalogue of stars. His final catalogue, containing 1,942 entries down to sixth magnitude, was published posthumously in 1763 under the title *Coelum Australe Stelliferum*, accompanied by a revised map with the names of his new constellations in Latin (the original names had all been in French).

In addition to inventing 14 new figures, Lacaille also divided the unfeasibly large Greek constellation of Argo Navis into three parts: Carina, the keel or body; Puppis, the poop (stern); and Vela, the sails. Were the three parts to be reunited, the resulting figure would be over 25 per cent larger in area than the current largest constellation, Hydra.

▲ Lacaille's 14 new southern constellations were first seen on this large planisphere painted by the French artist Anne-Louise Le Jeuneux in 1754

It is sometimes said that Pyxis, the mariner's compass, was a fourth subdivision of Argo, but in fact it was one of Lacaille's own inventions. In 1844, John Herschel, who knew the southern sky well after four years observing at the Cape, proposed replacing Pyxis with Malus, representing the mast of Argo, but it was Lacaille's invention that stuck. In fact, no further constellations were added to either the northern or southern skies after Lacaille's time.

Today, when we look at the southern sky, we see not so much "somebody's attic" but the results of over 150 years of endeavour. The southern constellations stand as a monument to those ancient explorers and astronomers who helped fill in our knowledge of the sky.

The French collection

The constellations introduced by Nicolas Louis de Lacaille in 1754

Constellation name	Representing
ANTLIA	Air pump
CAELUM	Chisel
CIRCINUS	Compasses
FORNAX	Furnace
HOROLOGIUM	Pendulum clock
MENSA	Table (after Table Mountain)
MICROSCOPIUM	Microscope
NORMA	Set square
OCTANS	Octant
PICTOR	Painter's easel
PYXIS	Compass
RETICULUM	Net
SCULPTOR	Sculptor's studio
TELESCOPIUM	Telescope

The fundamentals of astronomy for beginners

EXPLAINER

Solstices and equinoxes

Katrin Raynor explains how we get our seasons from Earth's orbit around the Sun

▲ **This month is the summer solstice – the longest day and shortest night of the year – still marked by many at the ancient site of Stonehenge**

For thousands of years, our ancient ancestors tracked the path of the Sun across the sky, watching it rise and set at different positions throughout the year and constructing monuments such as the prehistoric stone circle Stonehenge in Wiltshire to keep track of its movement. June is a key month in the Sun's path and also at Stonehenge, where thousands visit to mark the summer solstice – the longest day and shortest night of the year in the Northern Hemisphere.

The word 'solstice' comes to us from Latin, 'sol' meaning Sun and 'sistere' to stand still. But why does the Sun appear to stand still? And what does it signify in the astronomical calendar? Join me on a short journey as we follow Earth's orbit of our nearest star and learn why we experience seasons and variations in sunlight throughout the year.

We know that the changing position of the Sun in the sky is down to various factors involving the movement and position of our own planet over the year. Earth is 150 million kilometres from the Sun and orbits it along a slightly elliptical path at a speed of 107,208 kilometres per hour. One orbit takes approximately 365 days. Our planet isn't upright in its orbit; it's tilted at an angle of 23.4° and spins on an axis (an imaginary line that passes through the North Pole to the South Pole) at a speed of 1,670 kilometres per hour. One spin takes 24 hours. The tilt, rotation and elliptical orbit of Earth all give rise to changes in the amount of sunlight that we receive in each hemisphere throughout the year, and this is why we have seasons. When the top of Earth is tilted towards the Sun, the Northern Hemisphere experiences summer, while the Southern Hemisphere faces away and people there have their winter. Six months later and the seasons flip in each hemisphere.

Our seasons in the astronomical calendar are determined by two solstices and two equinoxes a year. A solstice occurs at the two points in Earth's orbit when our globe is at its maximum tilt either towards or away from the Sun. Equinoxes happen at the two points of the orbit when the Sun appears directly over the equator. The solstices and equinoxes divide the year into four parts: spring, summer, autumn and winter.

Katrin Raynor is an astronomy writer and a fellow of the Royal Astronomical Society

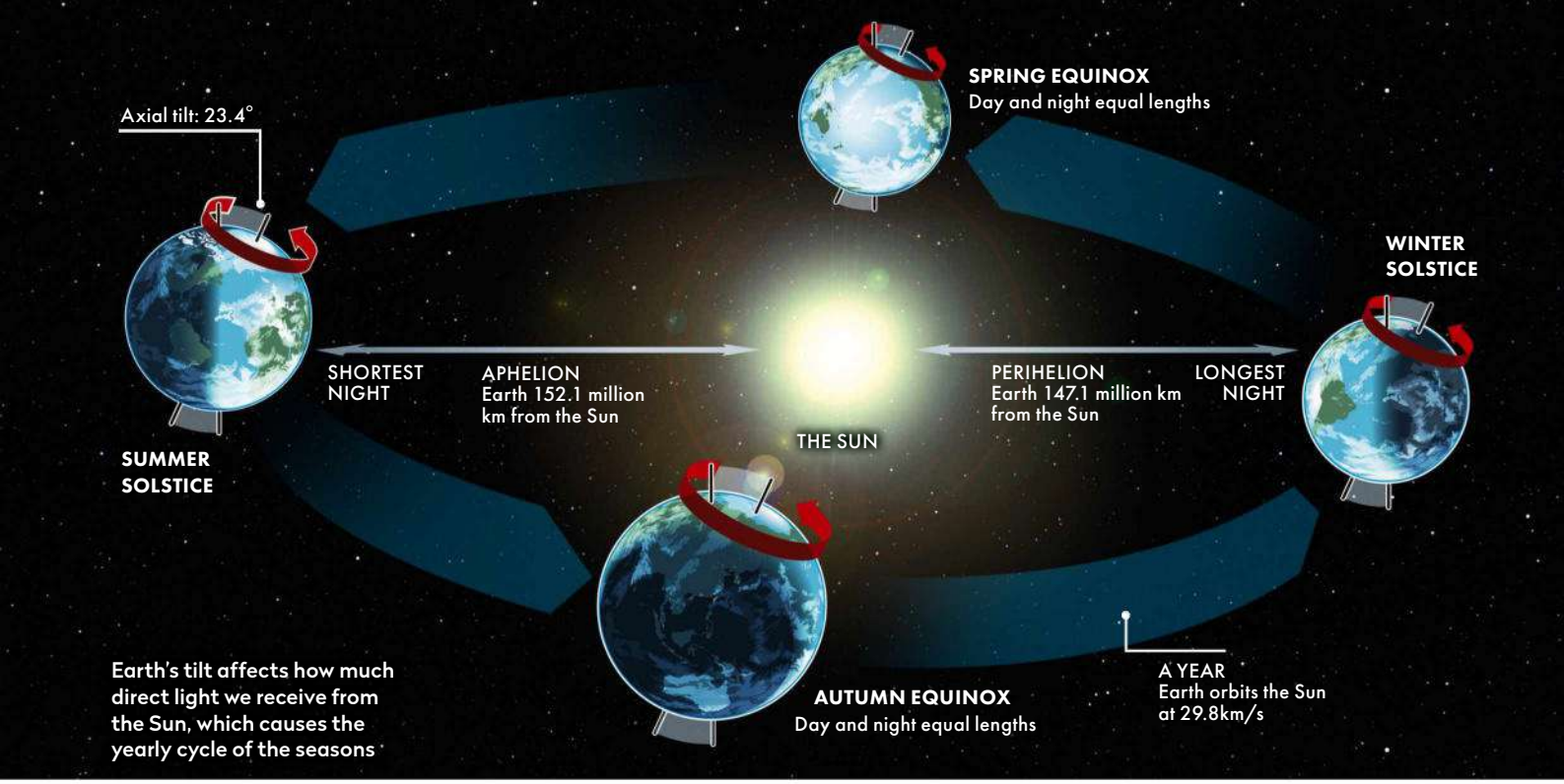
Built to tilt

The summer solstice occurs when that hemisphere's pole is tilted at its maximum angle towards the Sun. During this time, we experience a day with the longest period of daylight, 16 or so hours in the UK. This year, the summer solstice in the Northern Hemisphere falls on 21 June; on this day at 3:57pm BST the Sun will reach the most northerly point along its path through the sky (the ecliptic) before moving south again. This is what is meant by the Sun 'standing still'. The winter solstice is the opposite and occurs in December, when the North Pole is tilted at its maximum angle away from the Sun and the Sun reaches its most southerly point in the sky.

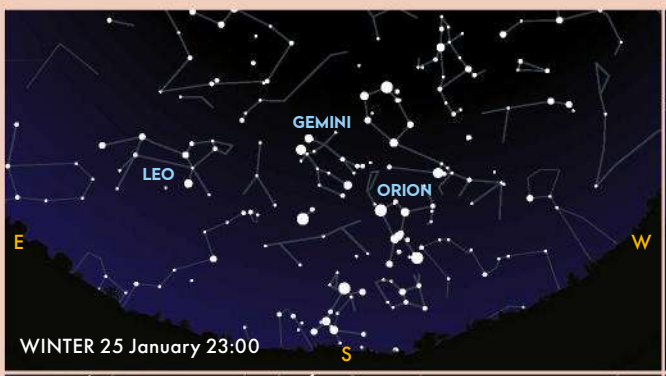
You might think that because Earth is tilted towards the Sun during the summer solstice, that that's when we are closest to our star. But this is not the case. In fact, the point at which our planet is closest to the Sun (perihelion) is in early January. On 21 June, Earth is actually nearing the point at which it is furthest away from the Sun (aphelion), in early July.

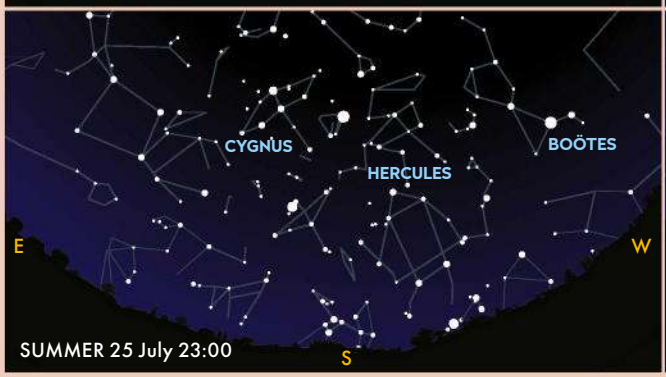
Falling between the summer and winter solstices are the spring and autumn equinoxes. 'Equinox' again

ROBERT HARDING/ALAMY STOCK PHOTO, EARTH ORBIT ILLUSTRATION BY ADRIAN DEAN


SPRING EQUINOX
Day and night equal lengths
Axial tilt: 23.4°
WINTER SOLSTICE
SHORTEST NIGHT
APHELION
Earth 152.1 million km from the Sun
PERIHELION
Earth 147.1 million km from the Sun
LONGEST NIGHT
THE SUN
SUMMER SOLSTICE
Earth's tilt affects how much direct light we receive from the Sun, which causes the yearly cycle of the seasons
AUTUMN EQUINOX
Day and night equal lengths
A YEAR
Earth orbits the Sun at 29.8km/s

comes from Latin and translates as 'equal night'. The equinoxes happen when Earth's axis points neither towards nor away from the Sun, a point when the Sun crosses the celestial equator going northwards or southwards depending on the time of year. The Sun is above the horizon for the same amount of time as it is below it. This year's spring equinox was on 20 March; the autumn equinox will be on 23 September.





World in motion

▲ It's Earth's motion through space that makes the constellations we see change throughout the year

Stars in the night sky are always changing – but it's us moving, not them

When you look to the night sky over the course of a year, you'll notice that it changes. Constellations not only shift their position from night to night, but come and go as the seasons change. Each season has its own sky, with its own prominent constellations – which is why Orion, for example, dominates the winter sky but is absent in summer. These changes are entirely due to the motion of Earth and are nothing to do with the stars far out in space. Earth is moving around the Sun by approximately one degree a day and at the same time is completing one rotation every 23 hours and 56 minutes. This is why we see the constellations shift westwards by one degree each night and rise in the east four minutes earlier. What this essentially means is that as Earth goes around the Sun spinning like a top, our view changes as we look out at different parts of the Universe at different times of the year.

DIY ASTRONOMY

Build your own EQ camera mount

A DIY equatorial mount to help you point your camera for astrophotography

It holds a standard DSLR, with simple 'setting circles' to help you aim

▲ Place the mount on a flat surface or on a regular photography tripod

This month's project is a manual equatorial mount that is enjoyable to use and helps to develop your knowledge of the night sky. Using RA and dec. (Right Ascension and declination) coordinates, it is possible to locate a faint target that might otherwise be difficult to see in your viewfinder. With an undriven mount, you are limited to relatively short exposures, but with a fast lens and high ISO setting, impressive night-sky images are certainly achievable.

The mount's RA axis must be aligned with Earth's axis of rotation, so you must adapt the downloadable plans to suit your latitude. At the North or South Poles, the RA axis would point vertically upwards, and at the equator it would be horizontal. For most of us, the angle between the RA disc and the ground is somewhere in between (90° minus your latitude).

Wrangle the angles

The dec. assembly pivots on the RA disc, but it is clampable with a wing nut when you're ready to take a photo. Similarly, the camera platform pivots on the dec. assembly, also with a clamp. The dec. scale is glued so that it reads 90° when the camera is pointing directly at the Pole. As the night sky appears to rotate, the RA scale must be free to turn, so you can adjust it. A strong bulldog clip holds it still while you move the dec. assembly between targets.

ALL PICTURES: MARK PARRISH

Mark Parrish is a bespoke designer based in West Sussex

To use the mount, it must firstly be polar aligned. Make sure the base is level, with the RA disc facing due north (in the Northern Hemisphere). To fine-tune the alignment, you can place a smartphone (with a planetarium app) on the RA disc and centre the displayed south celestial pole.

Next you need to move both axes so that the camera's viewfinder is centred on a known bright star (we'll use Vega as an example: RA 18h 37m, dec. +38.8°). The dec. scale should automatically read very close to 39°. Turn the RA scale so that it shows as close to 18 hours and 37 minutes as possible, then clamp it with the bulldog clip. Now you are ready to find your next target. Turn the camera (taking care not to dislodge the RA scale) to the coordinates of your new target and re-clamp the axes.

You can't do anything to adjust the image frame's orientation, but if your camera ends up awkwardly positioned, you can rotate both axes a full 180° to achieve a more acceptable setup (the dec. scale is repeated in both directions, and the RA disc has two pointers 180° apart).

Periodically you will need to adjust the RA scale to reflect Earth's rotation, but if you dial in the coordinates for the object that you are currently aiming at, you will have plenty of time to move to the next.

MORE **ONLINE**

Find additional photos and download plans to help with your build. See page 5 for details

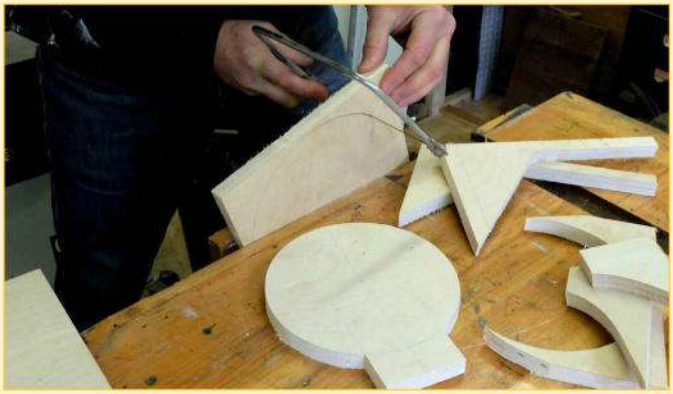
What you'll need

- Drill with bits: 6mm for the pivots, plus some larger ones to remove unnecessary plywood to save some weight
- Marking out tools, coping saw, scissors, craft knife, pencil, clamps
- 15mm good-quality plywood or similar (approximately 500 x 500mm)
- Two M6 x 40mm bolts (with wing nuts and washers)
- Stiff wire for the pointers
- Inexpensive tripod mount and camera plate, or 1/4-20 threaded screws
- Large bulldog clip to hold the RA scale
- Spray paint, wood glue

Step by step

Step 1

Using our downloadable plans (adjusting them for your latitude), carefully mark out all the parts. By 'nesting' the shapes, you'll be able to make efficient use of the board. Mark the centres of the pivots for drilling by pushing a sharp point into the wood.



Step 2

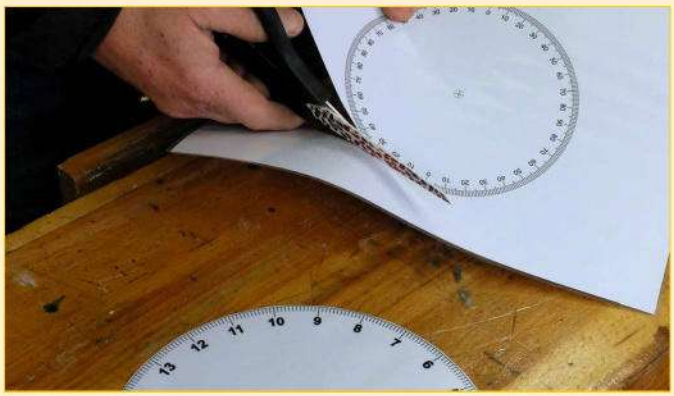
Carefully cut out the pieces. A coping saw is fine, but if you have a jigsaw or bandsaw, you can speed things up. You could tape the two sloping base parts together while cutting, so that they come out identical. Sand all the parts smooth.

Step 3

Drill the central 6mm-diameter pivots holes, then use larger drills to remove unnecessary plywood to keep the overall weight down. If you space these carefully, they can look aesthetically pleasing too! We chamfered all of the edges as well.

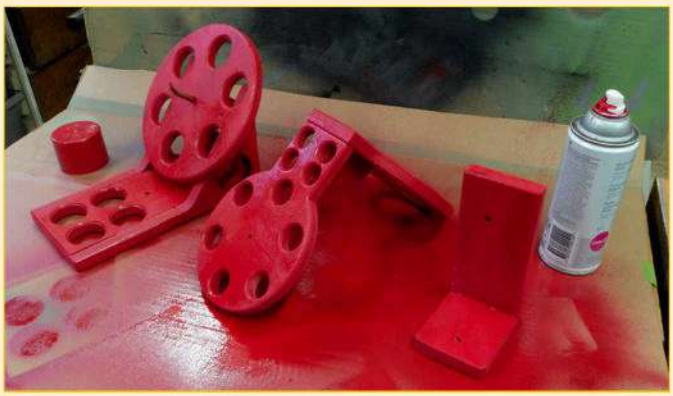
Step 4

The three main parts all need to be glued together. A good selection of clamps helps, but you can get by with masking tape. You can use dowels or screws to strengthen the joints, but be sure to drill pilot holes or the wood might split.



Step 5

Print off and cut out the scales (we laminated ours too), with punched central holes for the pivots. We used thin wire to make our pointers. We drilled small holes in the edge of the wood and pushed them in, then bent and cut them to size.



Step 6

After a final sanding, carefully paint or varnish your parts. After assembly, we added an inexpensive tripod mount to hold the camera and a camera plate that fitted our tripod. Alternatively, use 1/4-20 threaded screws to hold the camera to good effect.

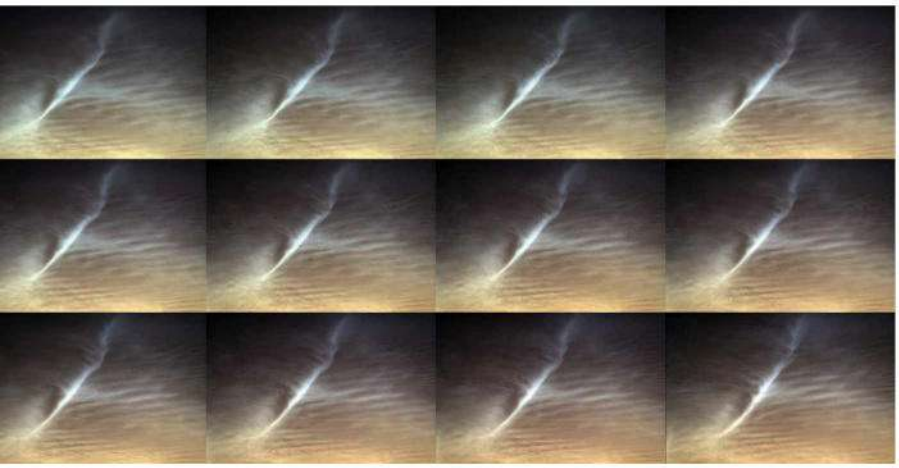
Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY

CAPTURE

Record the motion of NLCs

Capture the movement, structure and colours of summer's night-shining clouds



▲ **Pete's sequence of close-ups of an NLC rift structure. Subtle changes in the clouds look dramatic once animated and speeded up**

The lack of truly dark skies is an issue for the UK at this time of year. Some compensation is the chance to see noctilucent cloud (NLC) displays, and this month we'll look at how to photograph them to capture their structural movement.

NLCs are high-altitude ice-sheet clouds able to reflect sunlight despite the Sun being below the horizon from ground level. They are typically seen 90–120 minutes after sunset, low above the northwest horizon or a similar time before sunrise, low above the northeast horizon. Extensive displays may last all night, tracking from the northwest, through the north and ending in the northeast.

There are many interesting things about NLC displays, including their brightness, colour and different types of structure. This can all be seen visually, but recording displays with a camera allows you to create timelapse movies that show how NLCs develop over time and how their structures move. This isn't particularly complicated to do and the results can be quite stunning, revealing aspects of NLCs that you may not have realised were there.

Let's consider the basics of an NLC capture setup, starting with the obvious: a camera that is capable of capturing them. Adjustment to the camera settings should allow a fair bit of control to get the best image possible. You should also bear in mind that NLCs appear against a twilight sky. This is one of the most challenging backgrounds in astronomy, as light levels are constantly changing, meaning you need to stay sharp to avoid under- or overexposure.

A wide lens is ideal for capturing panoramic views of a display, but will also reduce the size of cloud structures and the apparent speed of any movement. A telephoto lens may not give the most stunning panorama, but it can help reveal rapid structural and drift variation in NLC formations.

Cameras sensitive enough to capture movies of NLCs offer another exciting capture method, but be prepared to speed up the output to get the full effect. Although NLC movement can be rapid, typically it's slow and subtle. Some smartphones have now reached the point where their cameras can easily record NLC displays. Auto settings may work, but do experiment with manual settings if you can, as you may get a much better result.

A stable platform is essential for animation captures. For regular cameras, this typically means a tripod, although a solid surface that allows you to point your camera in the right direction would do just as well. For smartphones, a tripod with an inexpensive phone holder adaptor is the way to go. As ever, the best way to take shots without getting motion blur when you press the shutter release button is to use a remote shutter release. For many smartphones, a good hack for this is to use a headphone lead with a volume control. Connect one to your phone and, with the camera app running, see whether pressing the volume up button triggers your camera's shutter. If it does, you've got a useful shutter release cable.

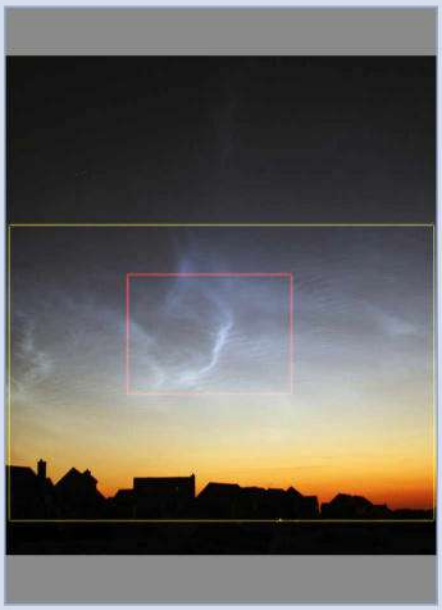
Equipment: DSLR or equivalent on a tripod; alternatively, a sensitive, night-capable smartphone

Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

✉ **Send your images to:**
gallery@skyatnightmagazine.com

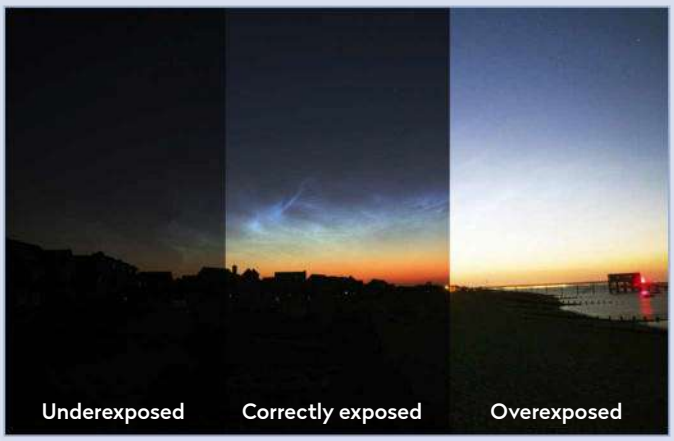
ALL PICTURES: PETE LAWRENCE

Step by step



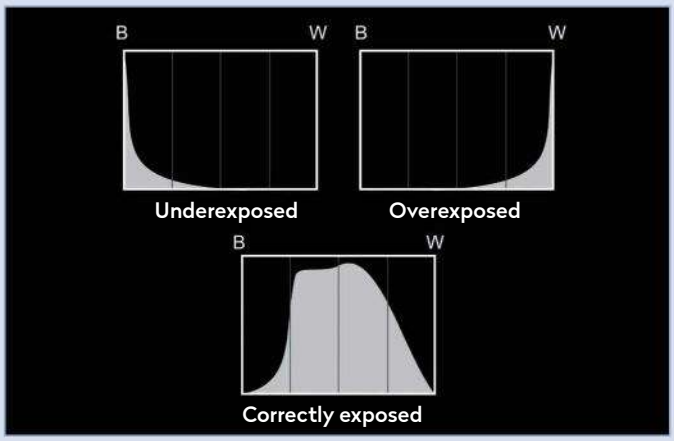
STEP 1

You can achieve panoramic views using short-focal-length lenses, but their structure and motion may lack impact in any animation you put together. A telephoto lens or even a low-image-scale telescope setup will get you closer to interesting features and will really exaggerate any motion. Better still, use two cameras and get a widefield *and* a close-up.



STEP 2

Use a fixed platform such as a tripod. Your camera settings will depend on the twilight's brightness. As a rule of thumb use a wide-open lens (low f/number) and low to mid ISO. Adjust so that for an evening display you get a bright first image; for a morning display, allow the first image to be slightly darker than usual.

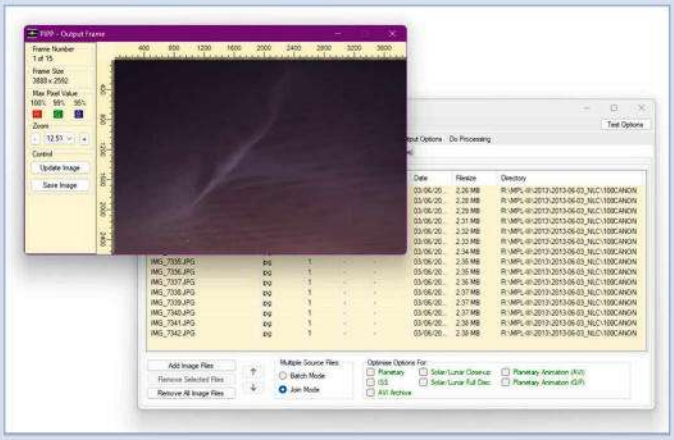


STEP 3

Monitor your exposures every few minutes. This can be done quickly if you adjust your camera to display the histogram as each image is taken. Make sure the histogram isn't pushed to one side of the graph area, creating a 'cliff-edge'. If it is, or it's approaching one side, make a quick adjustment to the settings.

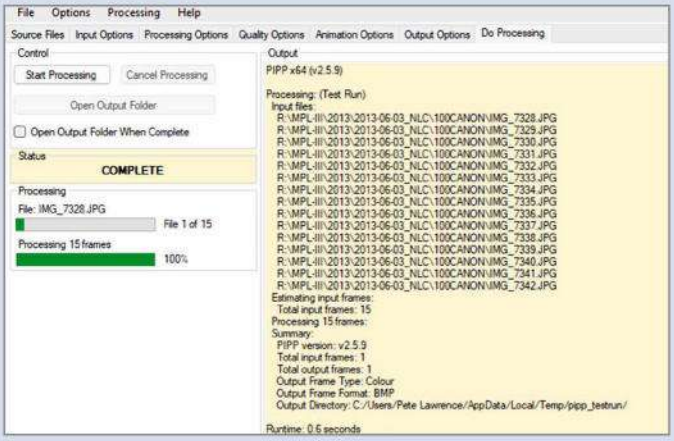
STEP 4

Rapid, repeated captures will produce smooth animations, but you'll get fewer chances to adjust the settings (see Step 3). The gap between captures should be smallest for close-up views, but can be longer for widefield shots (say, 10–20 seconds vs 30 seconds). An intervalometer makes light work of this if you have one. If not, you'll need to time and operate the shutter manually.



STEP 5

Once you have your captures, apply any adjustments across the whole batch. It's sensible to work on copies of your originals. Use a program like PIPP (**sites.google.com/site/astropipp**) for the batch adjustment and the animation build. Drop your captures into the source files tab, selecting 'Join mode'.



STEP 6

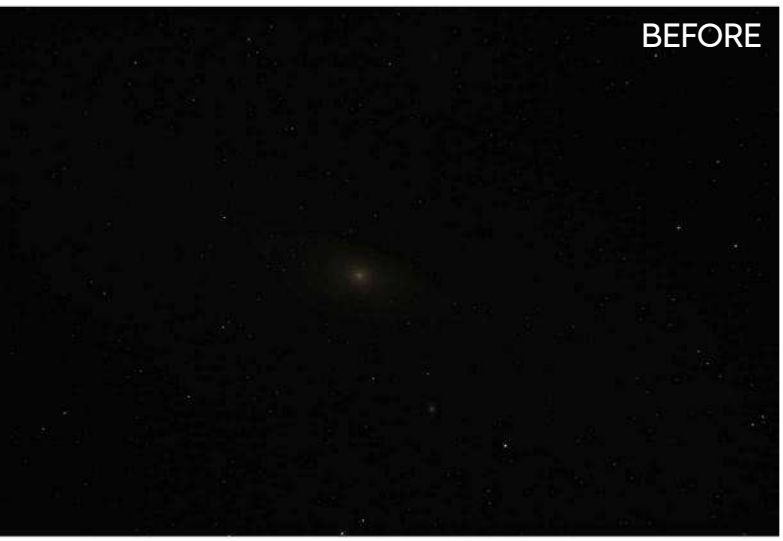
Use the 'Processing options' tab to make adjustments (your tweaks will appear in the preview image) and the 'Animation' and 'Output options' tabs to set these. Simply click 'Start processing' on the 'Do Processing' tab. Review your output and tweak options again as necessary to improve your results.

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

Fuss-free tools to process your DSLR astro images

Using freeware to stack, extract the background, calibrate colour and more



▲ Left: Charlotte's original stacked image, with the Andromeda Galaxy, M31 looking no more than a dark smudge. Right: after using Siril's 'Image processing' suite for common processing steps like enhancing the background and bringing out the galaxy's 'true' colour

ALL PICTURES: CHARLOTTE DANIELS

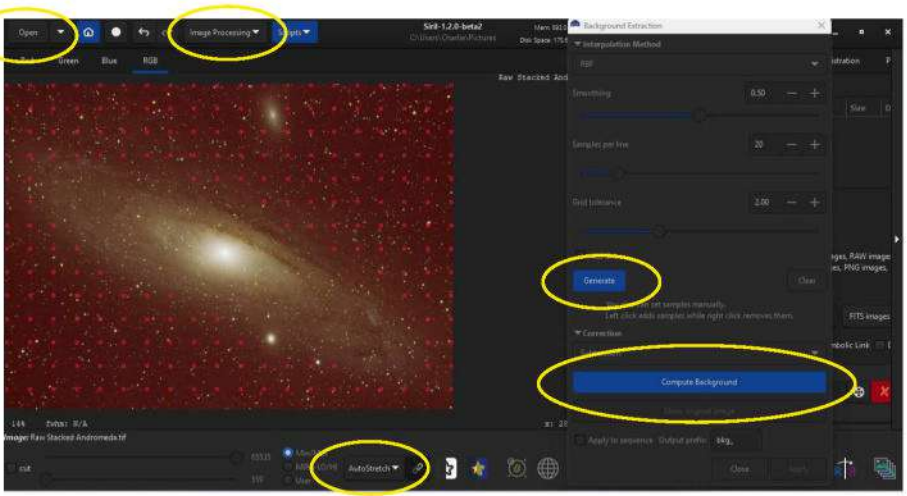
Astrophotography can be an expensive hobby and one where we constantly seek perfection from our data. While processing is a crucial step to achieving image excellence, many processing software packages come with the cost of monthly subscriptions. But that's not the case with astrophotography freeware Siril (**siril.org/download**).

Siril performs many functions including image stacking and autostretching, and it interfaces with external programs such as StarNet++ to remove stars too. This lessens the need to jump between various programs and simplifies the workflow for beginners. We won't focus on these functions, however, and will instead run though a few key features of Siril's 'Image processing' suite. The latest version of Siril, 1.2.0, was released in March 2023 and is available across Linux, Windows and macOS platforms. For this article, we installed the Windows 64-bit version.

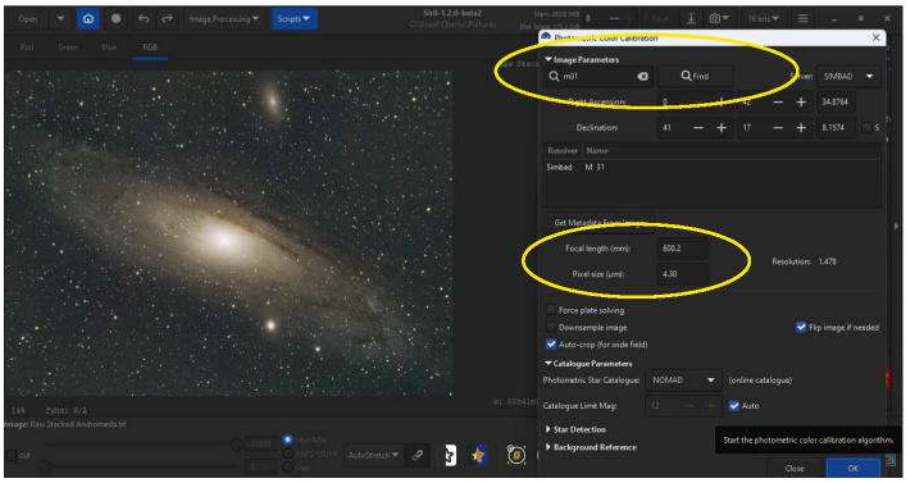
A bit of a stretch

To process our image of the Andromeda Galaxy, M31, we started by opening our stacked TIFF file (see Screenshot 1). By clicking the dropdown menu at the bottom of our screen (highlighted, Screenshot 1 and defaulted to 'Linear') and selecting 'AutoStretch', Siril performed a histogram stretch on our data, bringing the galaxy out from the initially dark and blank stacked image. We should note that this step doesn't actually perform an official auto-stretch; it is done for the purposes of showing us how much data is there and helping to inform our next processing steps. The actual stretch is applied later on.

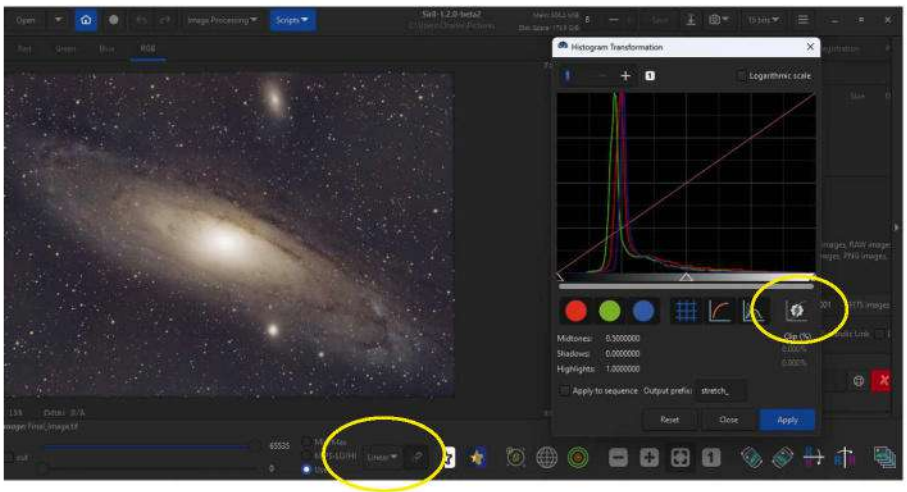
We were happy with the galaxy data, but the mock-autostretch showed significant background gradients. Next, we clicked on the 'Image processing' icon (highlighted) and selected 'Background extraction'. A pop-up window appeared (highlighted, Screenshot 1). Leaving the side bars as they were, we clicked the 'Generate' icon and red squares appeared across the image, showing where to focus our gradient removal. Naturally, we didn't want to remove details from our target, so we removed any squares that covered Andromeda by right-clicking on them. Once we were satisfied that they



▲ **Screenshot 1: The initial stacked TIFF image, opened and stretched using Siril's handy 'AutoStretch' function that highlights the areas that are going to need attention**



▲ **Screenshot 2: To balance the colour channels, 'Photometric colour calibration' is your friend. Input your target's catalogue name and your scope's focal length on this screen**



▲ **Screenshot 3: The final step was the true histogram stretch using Siril's 'Histogram transformation' function and, last of all, tweaking colour saturation and reducing noise**

only covered the background, we clicked 'Compute background'. This improved our background significantly.

We then performed a really neat trick that Siril has up its sleeve. Clicking back onto 'Image processing', we chose 'Colour calibration' and selected the 'Photometric colour calibration' (PCC) option. An adjustment menu appeared (see Screenshot 2). This tool is designed to balance colour channels in order to achieve the 'true' colours of a target as shown in catalogues, and does this through a process called plate-solving.

In order to work, PCC must be performed before a histogram stretch, as this part of the processing workflow can unbalance your colour channels. This is why we have the handy fake autostretch function available to us at the start of the workflow. In the adjustment menu window, we added the Messier designation for our target (M31) and clicked 'Find' (highlighted, Screenshot 2). Next, we added the focal length of the telescope we used for our image and the pixel size of our camera model (we simply looked this up online).

We then clicked 'OK' to start the calibration process, which took a couple of minutes to run. Our colour channels were automatically adjusted to provide a subtle, better representation of the galaxy. If afterwards there is any notable green left in the background of your image, you can run the 'Remove green noise' function (under 'Image processing') at this stage.

Finally, we performed the histogram stretch. Clicking back to linear mode on the dropdown menu (highlighted, Screenshot 3), we clicked 'Image processing' and selected 'Histogram transformation'. Clicking the furthermost right icon performed the autostretch. Our final image, which you can see on the page opposite, also had colour saturation and noise reductions performed (both under 'Image processing').

3 QUICK TIPS

1. Use the 'AutoStretch' option at the very start of your process to assess your data and help guide your adjustments.

2. If stacking files from multiple imaging sessions, crop your image straight after stacking, to avoid colour distortions.

3. Use the preview function within your adjustment window before deciding whether to apply a change.

Charlotte Daniels is an amateur astronomer, astrophotographer and journalist

Your best photos submitted to the magazine this month

ASTROPHOTOGRAPHY GALLERY

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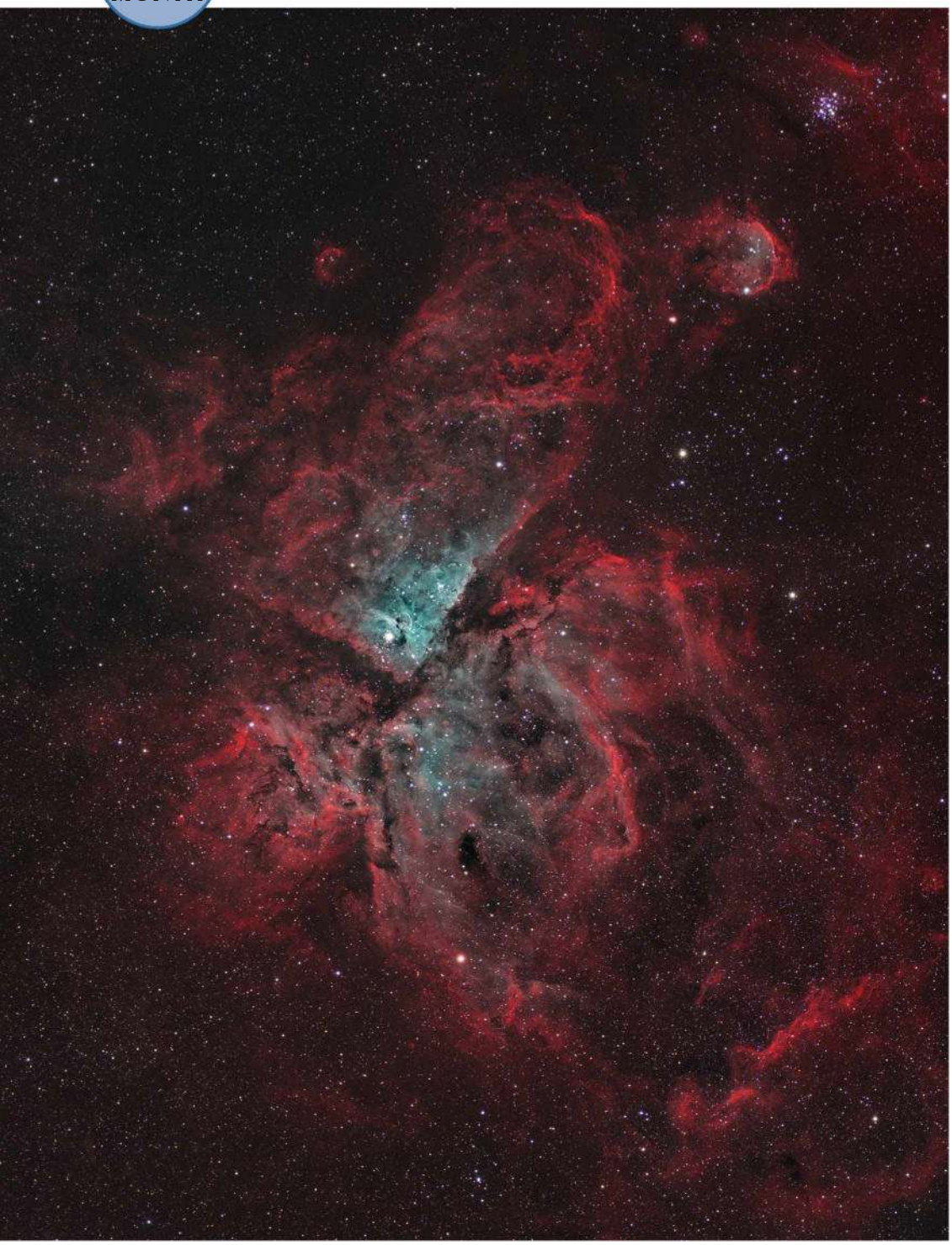
PHOTO OF THE MONTH



◁ The Carina Nebula

Emmanuel Valin, remotely via SADR Observatory, Coquimbo, Chile, 6/7 January 2023

Emmanuel says: "Getting remote access to the world-class skies of Chile was a way to escape the light pollution and cloudy conditions of my Paris area backyard. Once I obtained access to remotely image from the SADR Observatory, the Carina Nebula was at the top of my list of deep-sky objects in the Southern Hemisphere."

Equipment: QHYCCD QHY163M camera, TS Optics Imaging Star 71mm f/4.9 refractor, Sky-Watcher EQ8 mount
Exposure: Ha 40x 300" and 10x 600", OIII 10x 300"
Software: Siril, SiriLic, PixInsight, Photoshop

Emmanuel's top tips: "For anyone interested in starting astrophotography, my first tip would be to join an astronomy club. Experienced enthusiasts can offer guidance and potentially lend you equipment. Secondly, practise as much as possible. Even if you are limited by light pollution, focus on mastering your setup. As you gain experience, you can venture out to darker skies. Lastly, appreciate and enjoy every step of the process. The joy of astrophotography is not solely in the final image, but also in the journey. Consider each step a reward in and of itself, and any successful image as a bonus."

△ The Fireworks Galaxy with open cluster

Jared Bowens, Clarksdale, Missouri, USA, 19 June–28 October 2022

Jared says: "I'm quite pleased with the colours and details, and that I captured two objects in one image: NGC 6946 and, towards the upper right, the open star cluster NGC 6939."

Equipment: Canon 60D DSLR, Orion 8-inch f/3.9 Newtonian, Celestron AVX mount
Exposure: ISO 1250, 7.2h total
Software: DeepSkyStacker, PixInsight, Photoshop

△ The Milky Way

Egor Goryachev, Rooisand Desert Ranch, Namibia, 2 June 2022

Egor says: "It was a windy night when the Milky Way was setting in the west in the early morning, making a nicely shaped arch. I took this shot less than an hour before the morning twilight."

Equipment: Nikon D750 DSLR, Sigma Art 50mm f/1.4 lens, iOptron SkyGuider Pro mount **Exposure:** ISO 6400 f/2.8, 30"
Software: Starry Landscape Stacker, PixInsight, Lightroom, Photoshop

◁ The Spanish Dancer Galaxy

Sean Liang, archival data from El Sauce Observatory, Chile, March 2021–November 2022

Sean says: "I live in a tropical area where heavy clouds block the sky during the rainy season – nearly half the year! – so remote astronomy was my only option."

Equipment: FLI ProLine PL9000 camera, Planewave CDK24 astrograph, Mathis MI-1000/1250 mount
Exposure: 13h total **Software:** PixInsight, Photoshop

△ Aurora borealis

Andrew Parker, Reculver, Kent, 24 March 2023

Andrew says: "Reculver Towers on the Kent coast is an ideal dark-sky spot for looking north. Having seen a break in the weather, I decided to take the plunge and head out. I took a test shot as soon as my camera was set up and straight away the aurora revealed itself."

Equipment: Canon RP camera, Canon EF 24–70mm lens, tripod **Exposure:** ISO 3200 f/4, 8" **Software:** Photoshop

△ Venus after lunar occultation

Ismaeel Moinuddin, Lahore, Pakistan, 24 March 2023

Ismaeel says: "Venus led the Moon low into the western horizon, both glimmering through the parting clouds from recent rain."

Equipment: Canon 1100D DSLR, Celestron PowerSeeker 70AZ refractor and mount **Exposure:** ISO 6400 f/10, 1" **Software:** GIMP, Snapseed, Lightroom

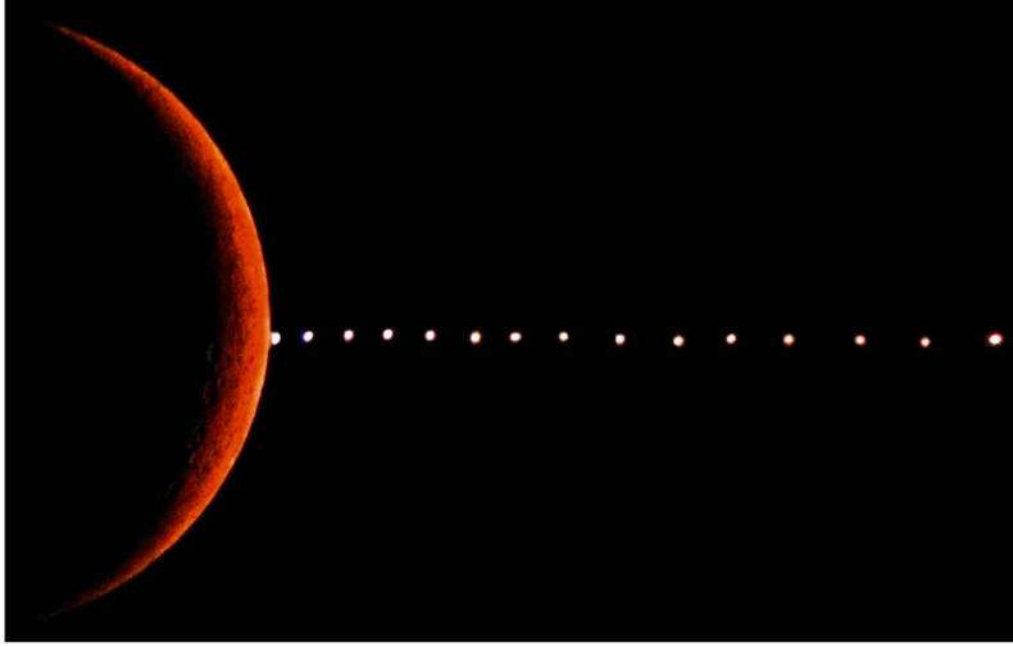
Milky Way over the Everglades ▷

Anthony Sleiman, Florida, USA, 24 February 2023

Anthony says: "In the foreground is a cypress tree called the Z Tree. Native Americans used to bend the trees like that to make markers, enabling them to explore the area without getting lost."

Equipment: Sony A7R III full-frame camera, Tamron 17–28mm lens, Artcise CS80C tripod **Exposure:** ISO 3200 f/2.8, 15" **Software:** Lightroom, Photoshop

Lunar occultation of Venus ▷



Shreya Roy, Kolkata, India, 24 March 2023

Shreya says: "I spent 1.5 hours capturing the distance of the Moon and Venus to make this 15-image composite that shows the entire event."

Equipment: Nikon D5600 DSLR, Nikkor 70–300mm lens, Digitek tripod
Exposure: ISO 800 f/6.3, 15x 1/10"–1/125"
Software: Lightroom, Snapseed

△ The Flaming Star Nebula with Tadpoles

Richard Guest, Kingwinsford, West Midlands, 14 March 2023

Richard says: "This was taken from my back garden. I was aiming just to capture the Flaming Star, but when I ran some sub-frames I could see the Tadpoles would fit nicely in the final image."

Equipment: ZWO ASI2600MC camera, Celestron NexStar Evolution 8-inch EdgeHD Schmidt-Cassegrain with Hyperstar
Exposure: 61x 59"
Software: PixInsight, Topaz AI

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86
Problem solved? Unistellar's one-click gloom-buster could be the cure for all your urban imaging irks

HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★½ Very good
★★★½★ Good ★★½★★ Average ★½★★★ Poor/avoid

PLUS: New astro gadgets and books on our obsession with Mars, exploring the Sun and observing the Universe

@THESHED/PHOTOSTUDIO

Unistellar eVscope eQuinox 2

Powerful, light pollution-busting smart scope for painless one-click imaging

WORDS: JAMIE CARTER

VITAL STATS

- **Price** £2,199
- **Optics** 114mm (4.5-inch) reflector
- **Focal length** 450mm, f/4
- **Sensor** Sony Exmor IMX347
- **Mount** Motorised single-arm, altaz, Go-To
- **Power** In-built lithium-ion rechargeable battery
- **Tripod** Aluminium, adjustable height
- **Ports** USB-C for power; USB-A for charging
- **App control** Unistellar (Android and iOS)
- **Weight** 9kg
- **Supplier** Unistellar SAS
- **Email** contact@unistellaroptics.com
- **www.**unistellar.com

Smart telescopes like the Unistellar eVscope eQuinox 2 have a lot in common with the smartphones used to control them. This new second-generation version of Unistellar's most affordable smart telescope comes with upgraded electronics, a new sensor and lots of new features – just as the latest smartphones tend to offer every year. But there are some genuine reasons to invest in this latest and greatest smart telescope.

As with its predecessor, eQuinox 2 has no eyepiece so no way of getting the original photons from stars, galaxies and nebulae into your eyes. This is about astrophotography. At its core, the eQuinox 2 is a 4.5-inch (114mm) reflector telescope mounted on a motorised altazimuth mount that autonomously aligns with, and tracks, the night sky.

Inside is the latest Sony IMX347 image sensor, which is used to take short exposures of deep-sky objects. Its onboard computer then stacks those images in real time, gradually revealing an ever-clearer image, with greater contrast, on connected smartphones and tablets. It's then easy to share framed (and auto-captioned) images and JPEGs on social media, though it's also possible to take lossless images in raw formats to store on the eQuinox 2's 64GB hard disc.

Easy does it

If you think smart telescopes like the eQuinox 2 are controversial then you may be behind the times. It's modelled on how most robotic professional telescopes work and, besides, it's difficult to imagine that the cutting-edge Autonomous Field Detection technology it uses won't soon dominate the telescope market. Autonomous Field Detection is a thing of beauty. With its nine-hour onboard battery recharged using a USB-C cable and its lens cap ▶

Be a citizen scientist

Unistellar's eVscope range of smart telescopes – of which the eQuinox 2 is the latest – are increasingly being used to crowdsource astronomical observations. Over 30 eVscope users around the world observed the impact of DART on Dimorphos and the behaviour of the asteroid immediately after the impact. Their findings were gathered and the users credited as co-authors on a paper published in the journal *Nature* in March 2023.

It's a big moment for smart telescopes, and scientific observations are now front and centre of the new Unistellar app. As soon as you've signed up, you can attempt to capture an asteroid occultation to help NASA's Lucy mission, confirm exoplanet transits spotted by NASA's Transiting Exoplanet Survey Satellite (TESS) and make observations of passing comets. In our test, it worked well for collecting data on comet C/2022 E3 ZTF for 20 minutes, though it's also very simple to enter your own coordinates if you merely want to image a comet or something off-catalogue.

@THESHED/PHOTOSTUDIO X 3, JAMIE CARTER

Field of view

At 34 x 47 arcminutes, the eQuinox 2 has a slightly wider field of view than its predecessor so can fit larger objects such as the Andromeda Galaxy, the Pleiades and the Moon. For now it can't image the Moon, but a firmware update promises to make that a feature in the future.

Mount and battery

The motorised altazimuth mount includes a rechargeable battery lasting 11 hours. It can be recharged via the USB-C cable and plug included in the box (third-party USB-C cables didn't work in our test). There's also a USB-C slot to allow a smartphone to be charged, but it's best to use a separate portable battery.

Dust cap/ Bahtinov mask

Inside the dust cap is a removable Bahtinov focus mask, which can be clicked into place on the front of the telescope tube. Point at a star and toggle the focus wheel on the other end of the telescope tube until the mask's diffraction spikes form a cross with a line passing through it.

Tripod

Each leg of this sturdy 2.2kg tripod has two extendable sections so it can be set up to stand alone at 133cm or on a table at 59cm. The clasps are strong and the tops of the tripod legs each have foam covers, which makes them easy to grip.

FIRST LIGHT

KIT TO ADD

1. Unistellar eVscope backpack

2. Portable battery to keep a smartphone charged up

3. Instagram app to share images

▶ removed, the eQuinox 2 images the stars above and plate-solves them with a database, automatically aligning in seconds.

If you've ever been frustrated when aligning telescopes, the eQuinox 2 is aimed at you. The only time it fails is if there's cloud, but even then it has to be thick cloud as, in our test, it aligned even when barely any stars were visible to the naked eye. However, it's not a completely autonomous affair; before making observations, it's wise to choose a bright star from its 37-million-strong database and use the Bahtinov focus mask hidden in the lens dust cap to achieve a sharp image by aligning the diffraction spikes of the chosen star.

Top murk-mastery

The eQuinox 2 is easy to use and that's partly thanks to an all-new version of Unistellar's control app that offers over 5,000 celestial objects ranked according to your location. With the eQuinox 2 pointed at the Orion Nebula, its Enhanced Vision technology performs a slow reveal of the detail within this huge star-forming region. Every few seconds, dustier detail, brightness and incredible colour within 6.2MP images is evident – and all this from the centre of a light-polluted city. Light pollution does make a difference when it comes to fainter nebulae, as does the sky transparency, though the main criticism of eQuinox 2's images will be that they're a little soft.

What this version can do that the previous couldn't is photograph larger objects, such as the Andromeda Galaxy and the Pleiades, thanks to its slightly wider 34 x 47-arcminute field of view. Another new feature on the eQuinox 2 is planet mode. It's something new for smart telescopes, which until now have been strictly deep-sky-oriented. During testing, only Mars was visible to us, though the results were lacklustre. Rather than the Enhanced Vision technique, planets use 'lucky imaging', whereby lots of very short exposures are taken in the hope of one being taken when the atmosphere is calm. Alas, that didn't prove possible.

Despite some new features and small upgrades, there are three reasons to buy the eQuinox 2: its automatic alignment, its incredible sensitivity (a limiting magnitude of 16 in light-polluted cities and 18.2 in rural skies) and its ability to pretend that light pollution isn't the big problem we know it is. If you live in or near a city and you want to get more from the deep sky, the eQuinox 2 is a fine way to go about it.

▲ **Above: With one click, the eQuinox 2 captured M81, Bode's Galaxy (top) in 26 minutes of data gathered from an urban location. The Orion Nebula (bottom) is from 16 minutes of data, making full use of the scope's Enhanced Vision tech**

Optics/image sensor

Light from distant galaxies, nebulae and star clusters goes from the 114mm mirror onto a Sony IMX347 sensor rather than into an eyepiece, all enclosed in a compact lightweight tube. A CMOS solid-state image sensor, it produces 6.2MP images in JPEG or raw formats.

VERDICT

Build & design	★★★★★
Ease of use	★★★★★
Features	★★★★☆
Go-To/tracking accuracy	★★★★★
Imaging quality	★★★★½
OVERALL	★★★★½

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FIRST LIGHT

QHYCCD QHY5III462C colour camera

Impressively premium sensor sophistication in a pocket-sized package

WORDS: CHRIS GRIMMER

VITAL STATS

- **Price** £229
- **Sensor** Sony IMX462 STARVIS CMOS
- **Resolution** 2.1MP, 1,920 x 1,080 pixels
- **Exposure range** 7ms–900 seconds
- **Connectivity** USB 3.0, guide port
- **Size** 36 x 36 x 80mm
- **Weight** 88g
- **Extras** Guide cable, USB 3.0 cable, 850nm IR and IR/UV cut filters, focus lock ring
- **Supplier** Modern Astronomy
- **Tel** 0208 7639953
- **www.**modernastronomy.com

Weighing in at under 100g, the QHY5III462C is a colour planetary camera that is also available as a mono version. It is certainly one of the more compact cameras in QHYCCD's collection, but this mini camera comes with some big features. Arriving in a single box, the QHY5III462C was nestled in a neat metal box not unlike an old-fashioned biscuit tin. Within, we found it well-secured in thick padded foam, with accessories including adaptors and filters stored snugly underneath. Inspecting the camera revealed it to be about the same width as a 1.25-inch eyepiece and a mere 80mm long.

Finished in a striking blue and with no plastic to be seen, the camera build was solid and very well-made, creating an excellent first impression. Positioned on the back of the camera and taking up most of the space is a USB 3.0 connector. The accompanying accessories include a USB 3.0 cable, focus locking ring, 1.25-inch infrared (IR)/ultraviolet (UV) blocking filter and a 1.25-inch 855nm IR pass filter.

Connecting the QHY5III462C to our 8-inch Meade telescope was easy, as the camera fits directly into the 1.25-inch adaptor on its focuser. By virtue of the Meade being a Schmidt-Cassegrain design, we had a very long focus range to take advantage of, making the process of focusing simple and quick. However, we did note that because the camera inserts into the focuser, this may cause issues with some refractors, which often require the camera sensor to be positioned further back. To combat this, a 1.25-inch nosepiece or extension tube (not supplied) can be directly screwed onto the front of the camera, which would grant the extra distance to achieve focus and would be a relatively simple fix.

Software simplicity

Before connecting the camera to our computer, we downloaded the driver package from the QHYCCD ▶

STARVIS sensor

The QHY5III462C utilises the sixth-generation Sony 2.1MP IMX462 STARVIS CMOS back-illuminated sensor. Being 'back-illuminated' means that the wiring structure within the sensor is below the photosensitive layer and doesn't block the path of any light. This, combined with Sony's new Super High Conversion Gain (sHCG) technology, produces a higher voltage from fewer photon results in a sensor that is extremely sensitive in low light.

Another benefit of the IMX462 sensor is its sensitivity to red and infrared light. Alongside its low-noise characteristics, this allows the QHY5III462C to capture upwards of 130fps at full resolution, even with an infrared pass filter installed.

It also supports 'Region of interest', which effectively lets you turn off areas of the camera sensor. This is especially helpful when imaging planets, as the outer areas are often blank space. By removing these areas, the file sizes are smaller, which allows for greater frames per second; we were easily achieving over 200fps when under 500 x 500 pixels.

ALL PHOTOS: @THESHED/PHOTOSTUDIO

IR pass and IR/UV cut filters

Included in the basic package is an infrared and UV cut filter. This filter is essential when imaging in normal colour, as the optical window on the camera doesn't include this protection. This has been done to ensure that maximum infrared sensitivity is maintained, as they also include a 855nm infrared pass filter.

Guider connection

A guiding cable is included, enabling the QHY5III462C to be connected directly to a mount and controlled via PHD2 or similar guiding software. The camera end of the connection is a solid metal connection that locks in place to avoid any accidental disconnection.

Connectivity

Equipped with a high-speed USB 3.0 connection and a large 512KB flash memory, the QHY5III462C can seamlessly capture and download large video files. The camera can capture up to 130fps in full-frame video and higher when using the 'Region of interest' function, due to the 5GB-per-second USB 3.0 interface.

Focus ring

Included is a fully adjustable solid metal ring that can be tightened to the barrel of the camera. This lets you lock the ring into a fixed position once focus has been achieved, allowing the camera to be inserted to the same distance time and again.

KIT TO ADD
1. All Sky lens
2. Methane (CH4) filter
3. Finder/guider adaptor

► website, which was a very easy task. QHYCCD has a single application to install all of its camera drivers, which made finding the correct one easy. Once installed, we loaded FireCapture and plugged in the USB 3.0 cable. FireCapture instantly connected, displaying the QHY5III462C live view on the screen.

With Mars a little small and Jupiter and Saturn too low for imaging, we targeted the Moon as the most detailed planetary body available. Initially we were surprised to only be recording 30–35 frames per second (fps). Adjusting the exposure time and gain had no effect, which suggested a data download issue. Delving into FireCapture's settings, we adjusted the 'USB traffic' option and, after some trial and error, we found reducing this to 5 (the default setting was 40) gave us the desired 130–135fps, while not overloading the image buffer. Monitoring the stats while the camera was running revealed that very few frames were being dropped and capture speeds maintained consistently above 100fps.

Fun with filters

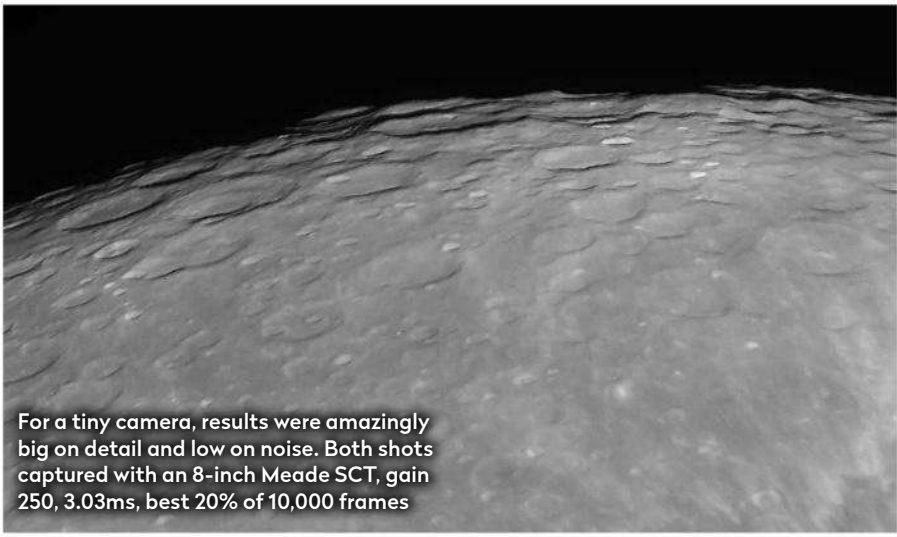
Testing out one of the QHY5III462C's strong points, we attached the included 855nm IR pass filter. This can be done by screwing the 1.25-inch filter directly onto the nose of the camera. Once reattached and focused we did notice that the Moon was dimmer than it was without the filter attached, but upon adjusting the exposure times to correct this, the frame rates remained around 120–130fps. Using the 'Region of interest' function, we were recording in excess of 200fps.

On the subject of file size, it is worth noting that at full resolution the QHY5III462C produces some very large files. A two-minute video of the Moon was around 15GB of data. This meant that after 40 minutes outside, we had over 120GB of data and our 250GB hard drive was getting very full. The file size also affected processing, as AutoStakkert! and RegiStax both struggled to process the larger files. However, once stacked the results were very impressive, with the stacked images showing very low noise and plenty of detail.

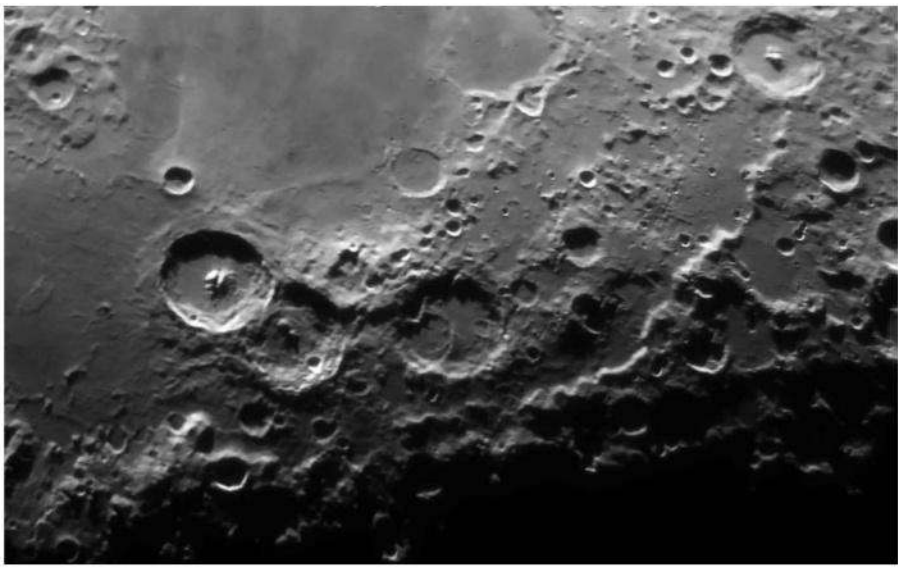
Overall, we were very impressed with the QHY5III462C, from excellent build quality to speed and a beautifully low-noise sensor. This little camera not only meets its specification, but far exceeds it.

Size

At a mere 80mm long and 36mm wide, the QHY5III462C is one of the smallest cameras available on the market, and at a mere 88g is also one of the lightest. Despite this low weight, there is no plastic to be seen and the camera feels very solid and well-made.



For a tiny camera, results were amazingly big on detail and low on noise. Both shots captured with an 8-inch Meade SCT, gain 250, 3.03ms, best 20% of 10,000 frames



▲ We got decent frame rates with an IR filter on board, after a little trial and error. The 'Region of interest' function lent a helpful hand

VERDICT

Build & design	★★★★★
Connectivity	★★★★½
Ease of use	★★★★★
Features	★★★★½
Imaging quality	★★★★½
OVERALL	★★★★½

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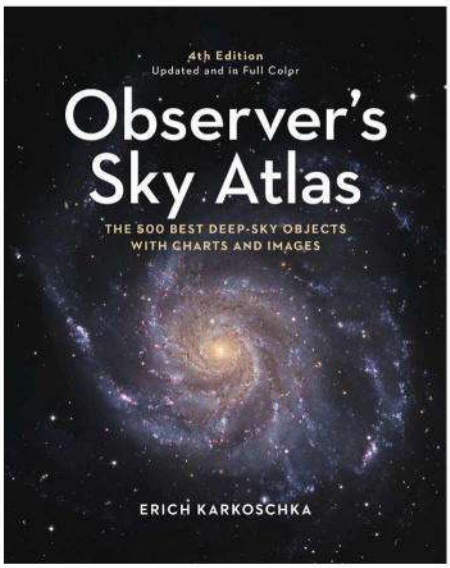
New astronomy and space titles reviewed

BOOKS


4th Edition
Updated and in Full Color
Observer's Sky Atlas
THE 500 BEST DEEP-SKY OBJECTS WITH CHARTS AND IMAGES
ERICH KARKOSCHKA

Observer's Sky Atlas

Erich Karkoschka
Firefly Books
£29.95 ● HB

Observer's Sky Atlas, written by astronomer Erich Karkoschka, has been an invaluable resource for both beginners and more experienced astronomers since 1990. First published in black and white, this indispensable night-sky atlas is now presented in its fourth edition: full-colour, expanded and revised using data from the ESA Gaia satellite. Crammed into its 144 pages are 500 deep-sky objects to observe, star charts and tables detailing lunar phases, planetary oppositions and fast-rotating binary stars up to the year 2060.

This new edition includes 61 new star charts and 532 images of galaxies, stars and nebulae – 415 of which are in full colour. Each object in the book can be viewed with the naked eye, binoculars or a small telescope, making it ideal for those starting out or who do not own powerful equipment. The amount of text in the book is minimal compared to other popular observing guides out there, so don't expect lengthy explanations about the objects you are viewing. However, this has enabled Karkoschka to produce an extremely detailed visual guide, allowing the observer to accurately locate each object by using the coordinates provided, along with identifying magnitudes and spectral types.

The inclusion of miniature photographs of objects listed in the tables provides easier identification through the eyepiece, making for fulfilling and successful sessions under the night sky. The coloured star charts are cleverly designed for daytime and night-time use. Under the light of a red torch, the differing colour contrasts allow the important objects to appear in high contrast and the less important objects in low contrast.

Access all areas: Karkoschka leads you to the best sights the Universe has to offer

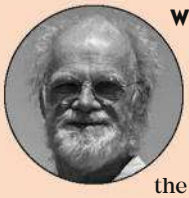
If you are a first-time reader of the *Sky Atlas*, you may find it takes a bit of getting used to. At first glance, the charts, numbering and abbreviations may leave you baffled. However, all the information you need is there. You just need to put a few hours aside to read the introductory pages, digest the explanations and get the best out of your observing time with minimal fuss. It's not hard to see why this is one of the most informative and best-loved sky guides. ★★★★★

***Katrin Raynor** is a writer and astronomer for BBC Radio Wales*

M-GUCCI/ISTOCK/GETTY IMAGES

Interview with the author

Erich Karkoschka



What are your favourite targets to observe in the night sky?

My favourites would have to be the Large Magellanic Cloud, nebulae such as the Carina Nebula, the Orion Nebula and the Swan Nebula, and the brightest of the globular clusters.

What advice would you give to anyone just starting their journey in practical astronomy?

My advice would be not to start observing the night sky with a telescope before you've made yourself familiar with the night sky using just the naked eye. Then you can maybe move on to using small binoculars, then larger binoculars. Otherwise, your first views through a telescope are without context, which makes it hard to comprehend what one sees.

We live in an age of Go-To mounts and stargazing apps. Is that a good thing?

Go-To mounts can certainly help to find and view interesting objects: they are a good addition to star-hopping. But trying to observe only with Go-To mounts is less satisfactory, since it is hard to bond with the night sky this way.

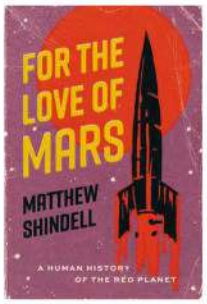
What should we be observing in the night sky for the rest of the year?

The summer sky has the most interesting objects in the Milky Way, so right about now is a good time to start exploring some of its targets. The giant planets Jupiter and Saturn will dominate the autumn sky, so we can turn our attentions there once the nights start getting longer again.

***Erich Karkoschka** is a planetary research scientist at the University of Arizona*

For the Love of Mars

Matthew Shindell
University of Chicago Press
£20 ● HB



"A malevolent planet, breeding anger and wars." That's how medieval physicians described our Solar System neighbour. "Mars causes men to spit blood, makes them melancholy, weakens their lungs, and causes itch or scurvy." People even believed the Red Planet was the cause of the Black Death. That's a very different view from the more recent idea of Mars as our next home planet, as advertised by SpaceX CEO Elon Musk, who wants to establish a one-million-person Mars city by 2059.

In this engaging book, historian Matthew Shindell, a curator at the Smithsonian National Air and Space Museum, takes his readers from antiquity to the Space Age, focusing on humanity's fascination with Mars throughout the centuries. By using Mars as a guidepost, Shindell walks us through the history of our changing world view, providing many little-known stories that you won't easily find in other astronomy books.

The second half of the book is more about space missions to Mars and is "more technical than [...] previous chapters", according to the author. But even here Shindell is more concerned with the human perception of our neighbouring planet than with anything else, alternating literature, science fiction and cinema with very accessible descriptions of Mars missions, from Mariner 4 to Perseverance.

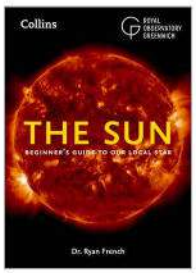
If you want a thorough scientific description of Mars exploration, this book won't be what you're looking for. But if you want to be surprised and inspired by humankind's fascination with the Red Planet, *For the Love of Mars* is a great read. ★★★★☆

***Govert Schilling** is a science writer and author of* Ripples In Spacetime

The Sun: Beginner's Guide to our Local Star

SOLAR SCIENCE

Ryan French
Collins
£8.99 ● PB



Our Sun is often considered to be an unremarkable star of average age. However, it regularly throws out huge eruptions of magnetised plasma that not only cause dazzling aurora displays but also wreak havoc on our technological systems. Unlike other stars, we can observe our Sun and the fundamental processes that occur on the surface and in the solar atmosphere with unprecedented detail.

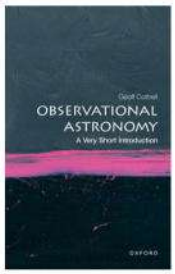
This book not only gives a concise and comprehensive guide to the physics of the Sun, its processes such as magnetic reconnection and their consequences here on Earth, but also how the physics relates to other stars and exoplanets. French provides a practical introduction and the necessary tools required to access and understand a multitude of high-resolution solar observations in different wavelengths, and how to safely observe the Sun from the comfort of your own home.

Beginning with a brief historical interlude on the mysteries of the Sun that plagued humankind for centuries – like whether dark sunspots on the surface were inhabitable regions of the Sun, or whether their numbers trended with the price of wheat – serves as a reminder that even the most accomplished scientists can make embarrassing mistakes as well as amazing, accidental discoveries. By the end of the story of sunlight, which includes spectacular images of sunspots, flares, prominences and solar eruptions both from a range of old and new space-borne satellites and ground-based telescopes, you will be left looking at our Sun in a whole new light. ★★★★★

***Stephanie Yardley** is a research fellow at Mullard Space Science Laboratory*

Observational Astronomy
A Very Short Introduction

Geoff Cottrell
Oxford University Press
£8.99 ● PB



Originally published in 2016 as *Telescopes: A Very Short Introduction*, this book has been completely revised to reflect the extensive field of the observational side of modern astronomy and astrophysics. The book now packs an astronomical punch. Although compact, *Observational Astronomy* nevertheless takes us on an insightful journey through the cosmos, exposing the current technology that enables us to see further and deeper into space than ever before.

Telescopes have probed beyond the narrow visible region of the electro-magnetic spectrum to reveal the Universe at radio, infrared, ultraviolet, X-ray and gamma-ray wavelengths. Whether on Earth or in space, whether large or small, whether working in collaboration – through interferometry or multi-messenger astronomy – or in isolation, innovative 'eyes on the sky' have revealed more and more exotic phenomena. With each exciting discovery, theory and observation have been inseparably entwined and more questions have arisen.

This volume explores dark matter, dark energy, the CMB radiation, subatomic neutrino particles, highly energetic cosmic ray particles and gravitational waves: ripples straining spacetime by as little as 1/200th the width of a proton but informing us of the violent mergers of black holes and neutron stars billions of lightyears away.

An extensive section on the Event Horizon Telescope and James Webb Space Telescope bring us bang up to date. This well-written, well-researched, fact-rammed book slips easily into your pocket. It's small but don't be misled; between its covers is the observable Universe and an in-depth technological odyssey well worth the read. ★★★★★

***Jane Green** is the author of the* Haynes Astronomy Manual

Ezzy Pearson rounds up the latest astronomical accessories

GEAR

1 Antlia OAG and filter drawer

Price £272 • **Supplier** 365 Astronomy
www.365astronomy.com

Simplify your astrophotography setup with this device that combines an off-axis guider (OAG) and a filter drawer system. The OAG has a 12mm prism with an adjustable height, while the filter slide comes with several adaptors to fit filters up to 50mm wide.

2 Constellation plate

Price £20 • **Supplier** Truly
www.truly.co.uk

Bring the heavens to your table with this plate depicting 13 constellations. Made from bone china and trimmed with 22-karat gold, it comes in both light and dark versions. A matching side plate is also available.

3 Gerd Neumann camera tilting unit XT

Price from €189.21 • **Supplier** Gerd Neumann
www.gerdneumann.net

Align your CCD or CMOS camera more precisely with the help of this unit. Designed to cope with larger cameras, it lets you adjust the focal plane's tilt quickly and precisely. A variety of threads are available.

4 Lowepro Tahoe backpack

Price £79 • **Supplier** Wex Photo Video
www.wexphotovideo.com

Keep your equipment safe while you're on the go with this well-padded backpack with a customisable layout for DSLRs, travel telescopes up to 36cm long and eyepieces. One side can be completely opened to allow easy access.

5 Altair Ha OIII dual band 6nm CMOS filter

Price £299 • **Supplier** Altair Astro
www.altairastro.com

ADVANCED As well as helping to increase the contrast of nebulae for both observing and photography, this filter cuts down moonlight and light pollution to give excellent views in both H-alpha and OIII.

6 William Optics smartphone holder

Price £119 • **Supplier** The Widescreen Centre
www.widescreen-centre.co.uk

For quick and easy photos with your smartphone through your telescope's eyepiece, this new holder will keep your camera in perfect alignment. Comes with a 72° eyepiece and can also be used to attach your smartphone to a tripod.

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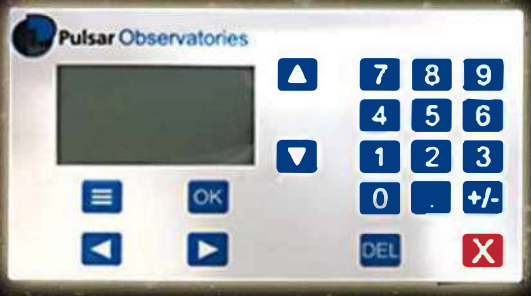

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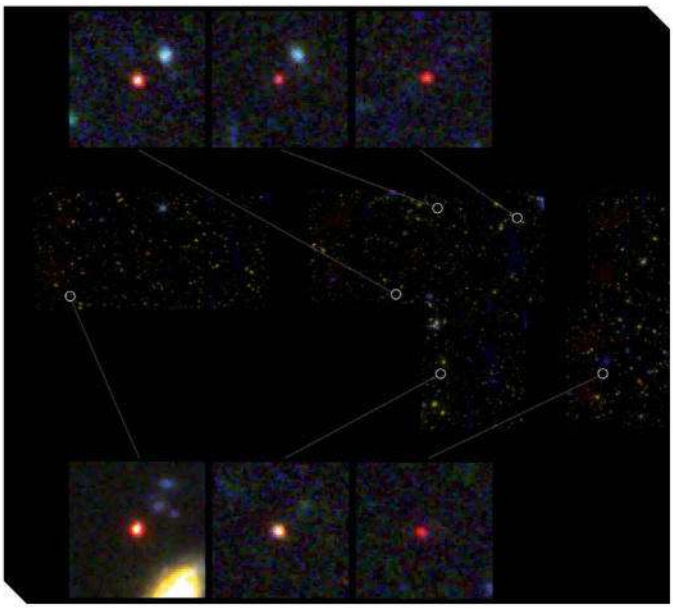
Anita Chandran interviews Professor Erica Nelson

Q&A WITH A GALAXY HUNTER

Researchers have been shocked to discover 'Universe breakers' in JWST images, massive galaxies that existed way before current theories predicted

What do scientists think the early Universe was like?
In the beginning there was nothing: no time, no space. Then the Big Bang happened and everything popped into existence – all the light and matter that exists in our Universe. The early Universe was a hot, dense, turbulent place and the kinds of objects that could form then were very different from those that could form today.

What was your research team looking for?
We were trying to see the first luminous objects in the Universe. The James Webb Space Telescope (JWST) was constructed to look back at the earliest cosmic epochs to search for these luminous objects. We don't yet know how far back in time they exist. We didn't think JWST would have the sensitivity to see individual stars, so instead we were looking for galaxies that are much more luminous.



▲ **Follow-up studies should reveal if the six bodies really are galaxies and whether they're as theory-shatteringly huge as they seem**

How did you make your discovery?
I was blinking back and forth between Hubble Space Telescope images and JWST images and noticed these fuzzy spots that were extremely red, bright and didn't exist in the Hubble images. We started trying to figure out what they were. We were analysing the data and found that one was a massive galaxy, very early in the Universe. Our collaboration then found more of these objects that looked like galaxies.

What era did these galaxies exist in?
The earliest is about 500 million years after the Big Bang. These early galaxies had the same number of stars as our Milky Way, shortly after the first stars formed. In comparison, our Milky Way has had 14 billion years to form: the entire history of the Universe.

Did you expect to see such galaxies?
We have theories of cosmology, one of which says the Universe began with a Big Bang 14 billion years ago. This theory makes predictions for how big galaxies should be able to get at a given era in the Universe's history. Based on those predictions, we did not think galaxies should exist at such early times as we discovered them; it's not possible in current theories of cosmology.

We call these galaxies the 'Universe breakers' because they shatter the notion that massive galaxies took billions of years to form, a fundamental precept of our understanding of the Universe.

What's next for researchers looking for these 'Universe breakers'?
First, we need to validate that one or more of these objects is a galaxy, because we've never seen such objects before. We'd also like to find more of them to determine if this is some kind of statistical anomaly; the Universe is big and the patch of sky that we looked at is small. The second is that we need to get more JWST data on these objects, mainly spectroscopic data, and that will tell us if they're real.

How will spectroscopic data confirm that they are galaxies?
Everyone says that an image is worth a thousand words but for us, a spectrum is worth a thousand images. With a spectrum we can tell if the light we see is due to, say, a quasar. It also allows us to confirm how far away these objects are and hence know how old they are.

If they're not galaxies, what else could they be?
We got additional data on one of the objects in December, and it turns out to be a baby quasar and not a galaxy. A quasar is a supermassive black hole that is eating the stars, dust and gas around it and converting that mass into energy. Quasars are incredibly luminous, some of the brightest objects in the Universe – not intuitive, given that they are black holes. It's possible that others could be quasars, though we have some evidence to the contrary.

We've thought of some exotic possibilities of what they could be, though it would be more exciting if it was something we hadn't thought about before. But if even one of them is a galaxy, that would be a challenge to our theories of cosmology.

Erica Nelson is an assistant professor of astrophysics at the University of Colorado, Boulder, studying the early Universe using the JWST

NASA/ESA/CSA/I. LABBE (SWINBURNE UNIVERSITY OF TECHNOLOGY)/IMAGE PROCESSING: G. BRAMMER (NIELS BOHR INSTITUTE'S COSMIC DAWN CENTER AT THE UNIVERSITY OF COPENHAGEN)

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

Track Comet Wild 2 as it passes three globulars, get some Pointers and stop for a Hamburger

When to use this chart

1 June at 00:00 AEST (14:00 UT)
15 June at 23:00 AEST (13:00 UT)
30 June at 22:00 AEST (12:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

JUNE HIGHLIGHTS

Comet 81P/Wild 2 is visible most of the night, rising in the early evening in Ophiuchus. Expected to be faint (11th magnitude) it might normally be difficult to track down. However, early in June it makes close calls to three globular star clusters that act as finders. On the evening of the 7th, Wild 2 is 0.5° south of NGC 6356 and on the 10th it's 1.2° north of NGC 6342. All this time it has been creeping up on M9, being closest on the evening of the 12th, only 0.2° northwest of this bright globular.

STARS AND CONSTELLATIONS

Alpha and Beta Centauri are often called the 'Pointers', but if you draw a line from the stars towards the Southern Cross (Crux) it passes over the top. Alpha has a high proper motion and is moving towards Beta with this line gradually pointing further south. Around AD 4000 the stars will be about 2° apart (half the current separation), with the line pointing at the centre of the Cross. Alpha will be closest to Beta in around AD 6200 – less than the diameter of the Moon away!

THE PLANETS

Venus has reached its maximum altitude above the northwest early-evening horizon. Venus and Mars start 10° apart, narrowing to 4° at month end. On 3 June, Mars passes in front of the Beehive Cluster with Venus following on 14 June.

Saturn has now entered the evening sky, arriving around 23:00 midmonth, followed by Neptune around midnight. Jupiter is prominent in the predawn northeastern sky. Uranus is rising before dawn, passing Mercury as it departs from morning skies.

DEEP-SKY OBJECTS

Centaurus is a constellation of contrast, ranging from its southern region immersed in the Milky Way environs to its northern area with a more extragalactic flavour. Centaurus is home to the two brightest members of the Centaurus A galaxy group, NGC 4945 (RA 13h 5.4m, dec. –49° 28') and NGC 5128 (RA 13h 25.5m, dec. –43° 01'). NGC 4945 is located between the fourth-magnitude wide pair of stars, Xi¹ and Xi² Centauri.

This distinctive ninth-magnitude, edge-on spiral (22 x 2 arcminutes) looks like a white streak at low powers. Its surface appears mottled, brightening towards its equator, with an ill-defined core. In contrast, seventh-magnitude NGC 5128 (also known as 'Cen A') appears roughly circular (15 arcminutes) with a prominent wide, dark equatorial band cutting the galaxy in half, leading to its nickname, the Hamburger Galaxy.

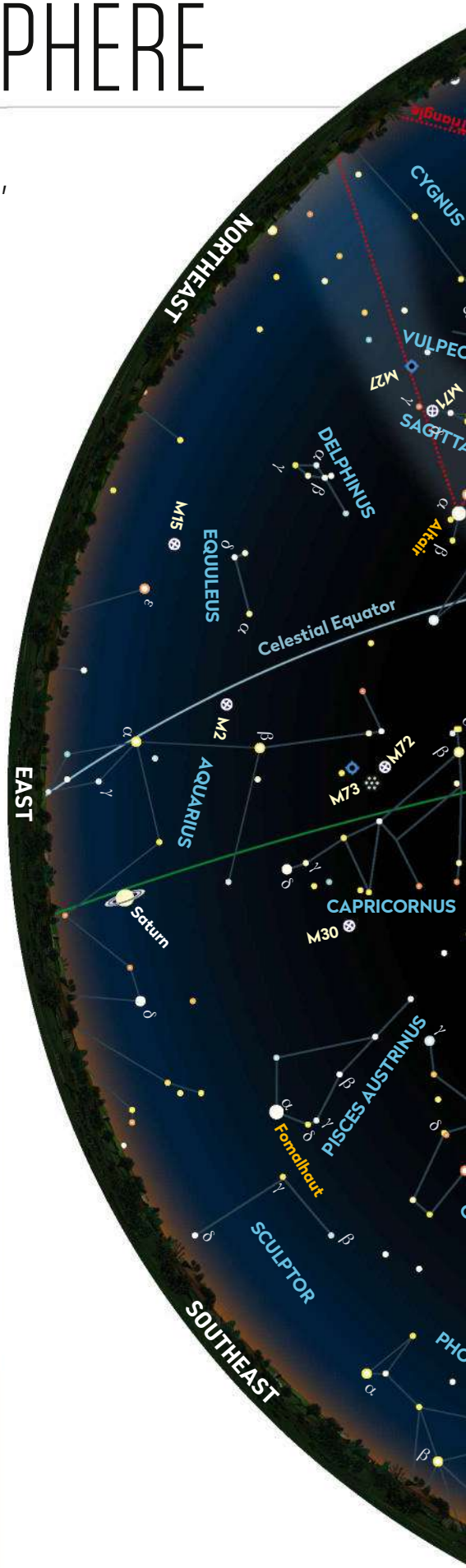

Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE

NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
HERCULES
M92
Vega
LYRA
Keystone
M13
Albireo
CYGNUS
Summer
BOÖTES
Kite
CORONA BOREALIS
Arcturus
M3
COMA BERENICES
M53
Realm of Galaxies
M100
M58
M87
M86
M60
M61
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M107
M11
SCUTUM
M16
M17
M18
1 Jun
M9
81P Wild (Wild 2)
30 Jun
M23
M20
NGC 6356
NGC 6342
M8
M4
Antares
4th
30th
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